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Kimijima et al.

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(54) **IMAGE CAPTURING APPARATUS AND IMAGE PROCESSING METHOD**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**

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G03B 13/36	(2006.01)
H04N 5/357	(2011.01)
G02B 7/34	(2006.01)
H04N 5/232	(2006.01)

(52) **U.S. Cl.**

CPC ***H04N 5/23212*** (2013.01); ***G03B 13/36*** (2013.01); ***H04N 5/3572*** (2013.01); ***G02B 7/34*** (2013.01)
USPC **348/222.1**

(58) **Field of Classification Search**

USPC 348/222.1
See application file for complete search history.

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(57) **ABSTRACT**

An image capturing apparatus comprises an image sensor comprising an imaging pixel for receiving light through an opening with a center position coincident with the optical axis of a microlens, first and second focus detection pixels for receiving pupil-divided light through a first and second opening offset in first and second directions from the optical axis of a microlens, respectively; ROM for storing shading correction data; correction coefficient generation unit for generating shading correction coefficients respectively for the imaging pixel, and the first and second focus detection pixels from the shading correction data; and correction unit for subjecting a signal for the imaging pixel to shading correction with the use of the shading correction coefficient for the imaging pixel, and subjecting signals for the first and second focus detection pixels to shading correction with the use of the shading correction coefficients for the first and second focus detection pixels.

10 Claims, 15 Drawing Sheets

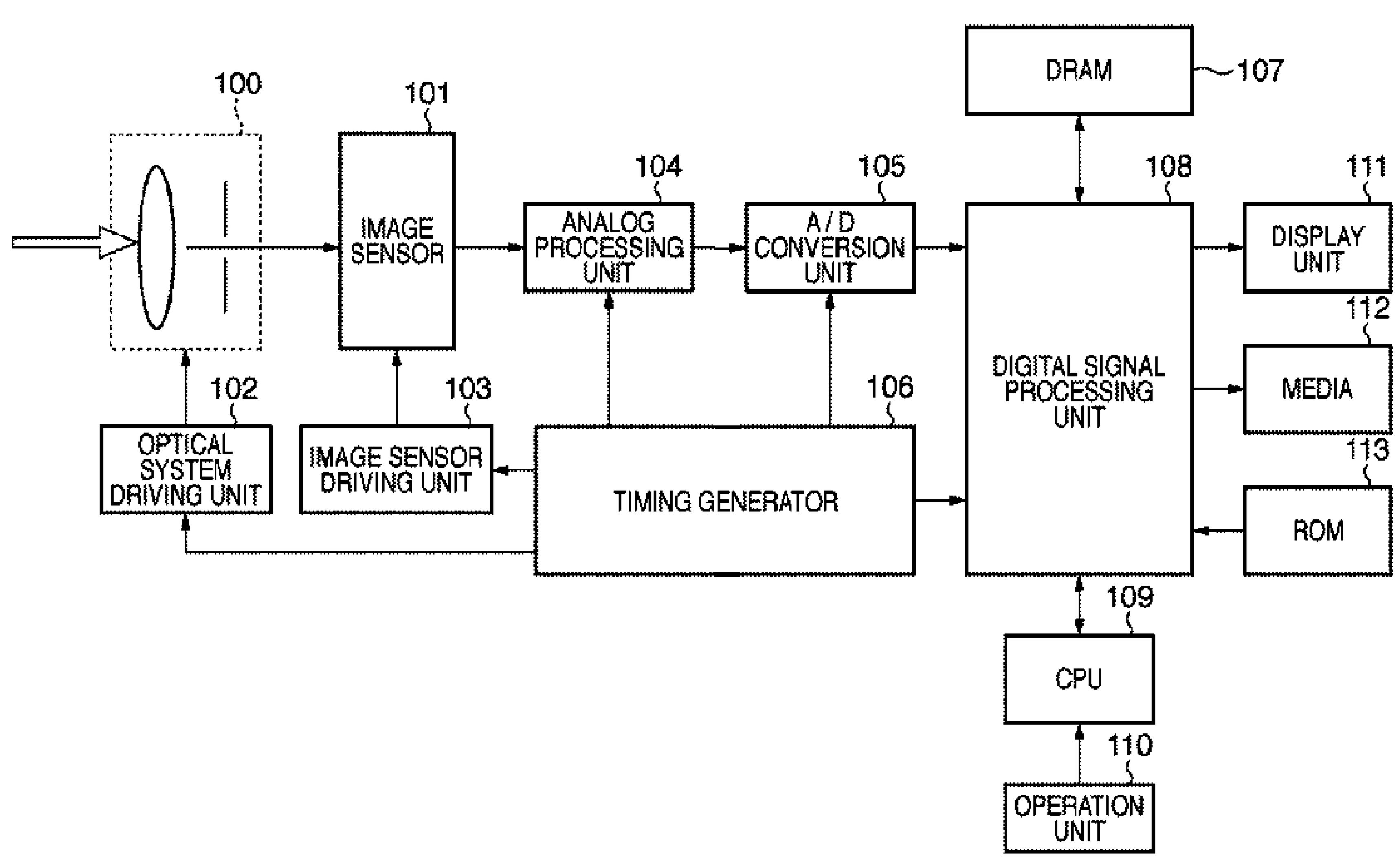

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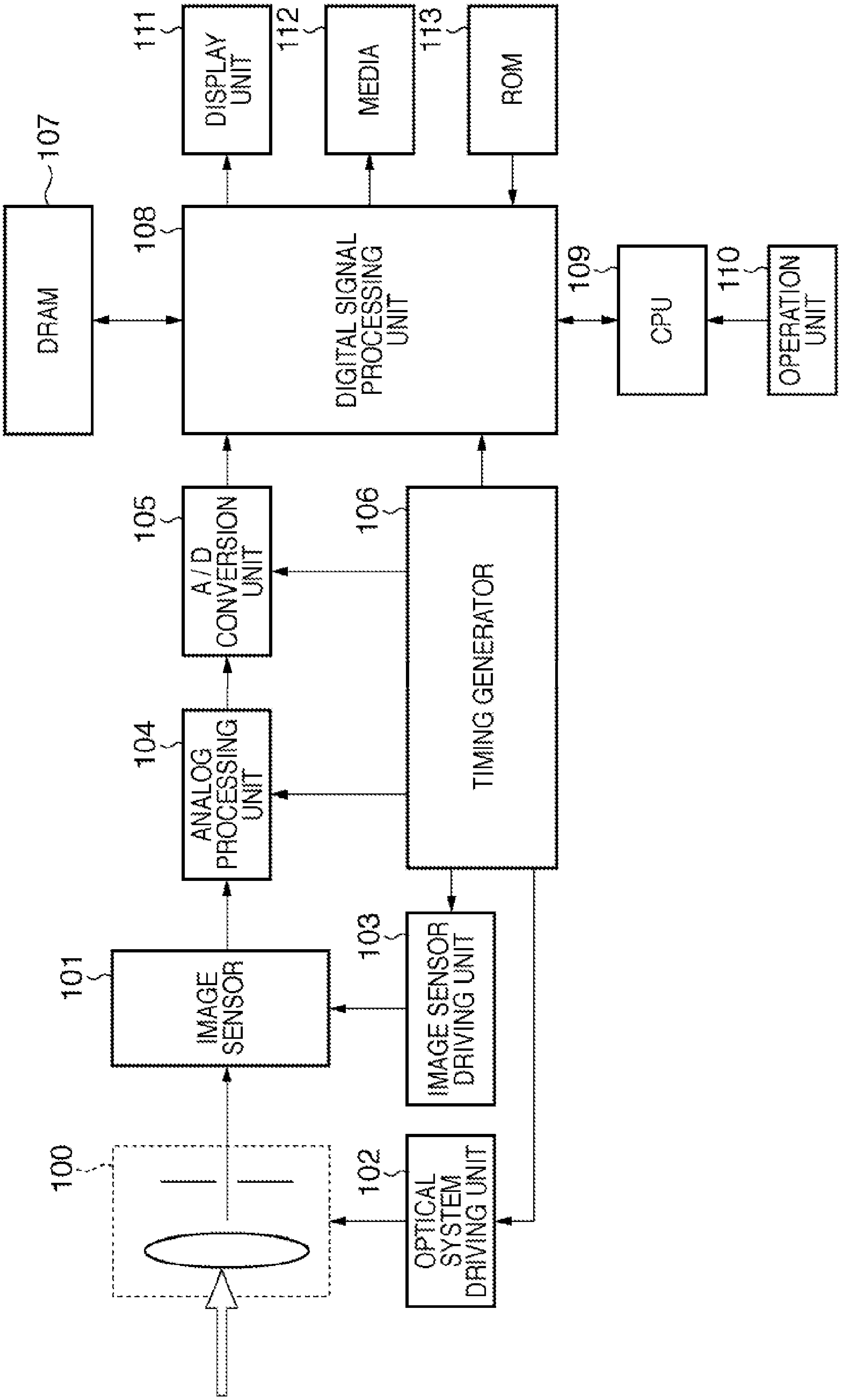
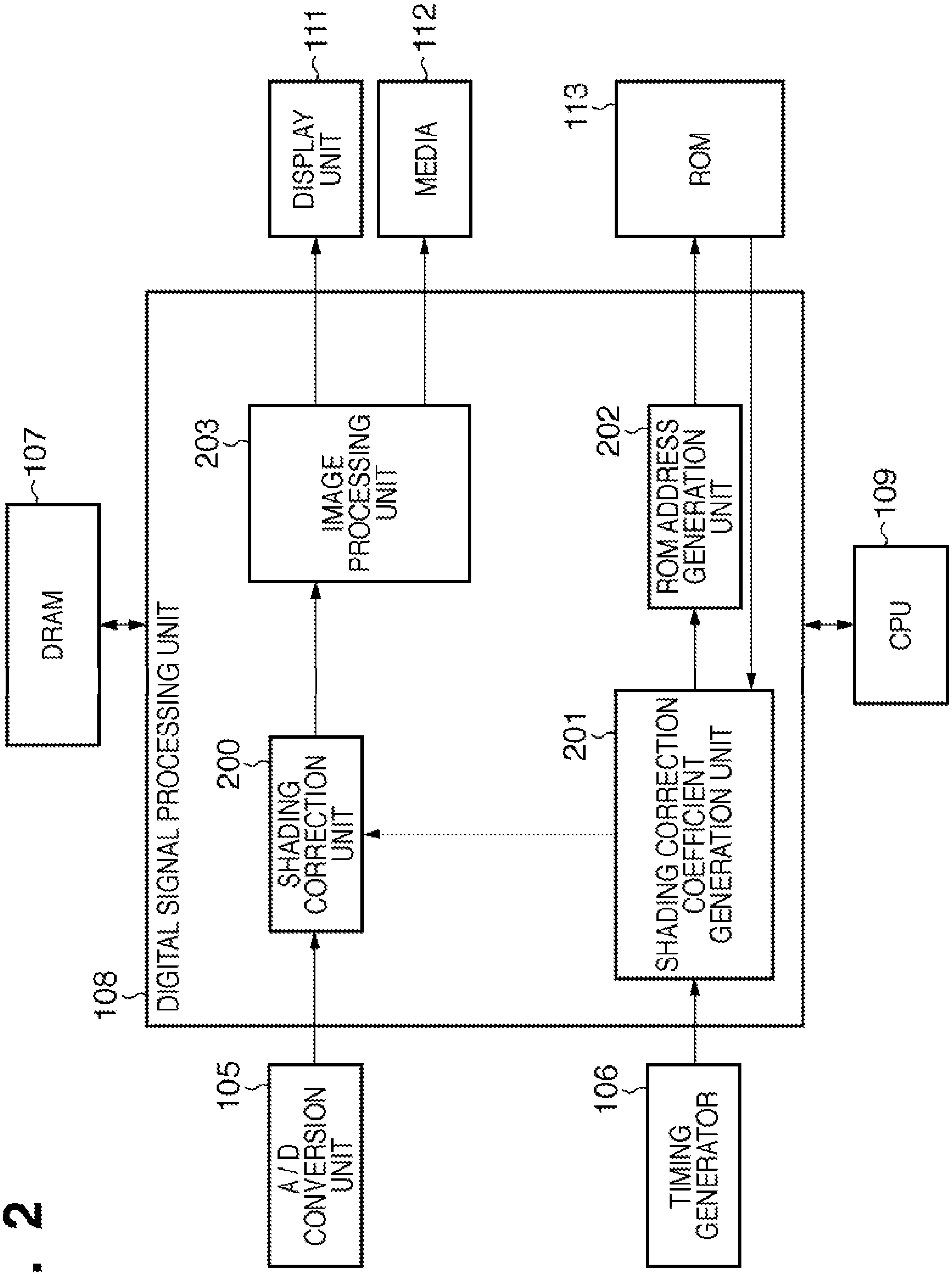
FIG. 1

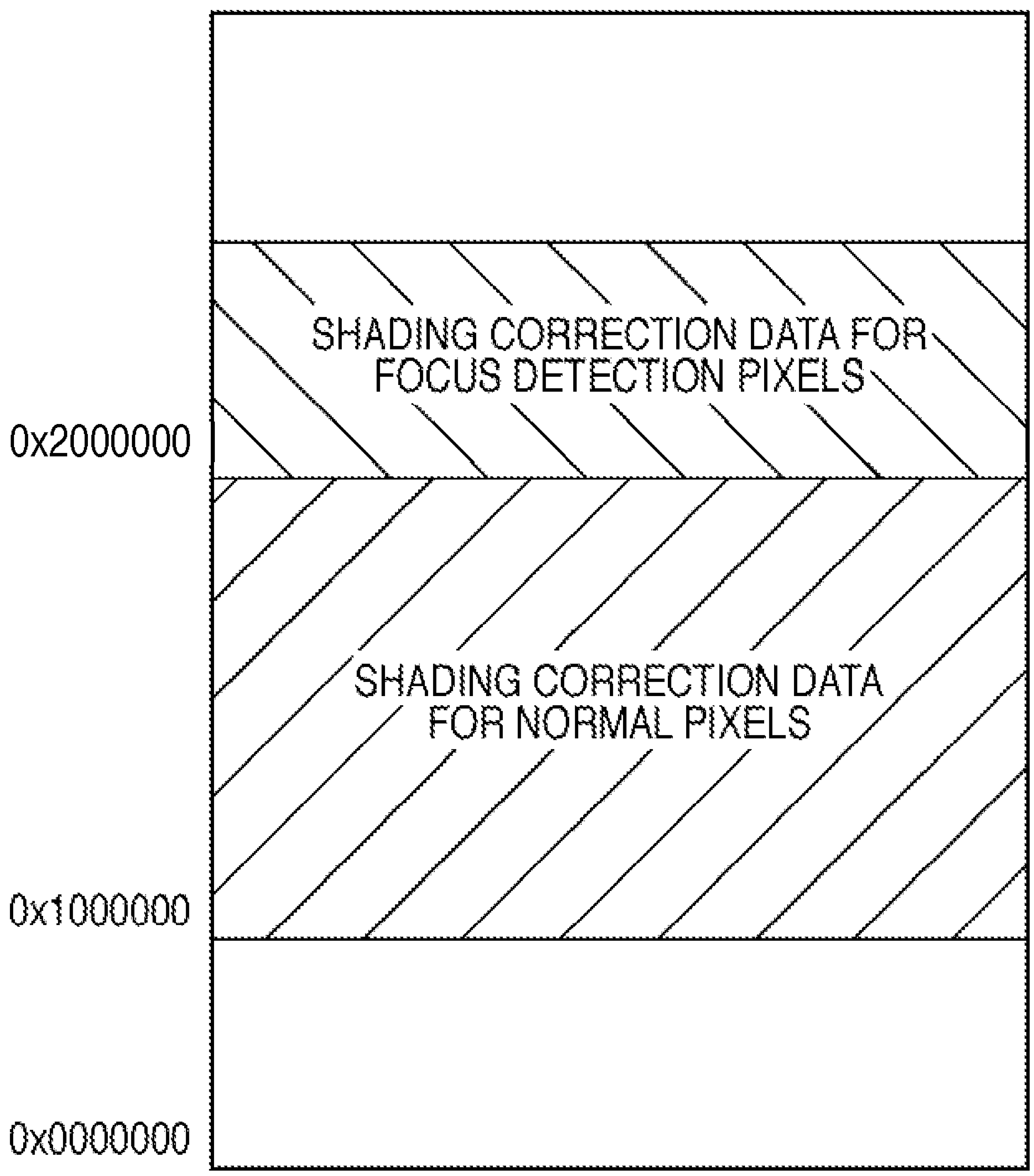

100
101
IMAGE SENSOR
102
OPTICAL SYSTEM DRIVING UNIT
103
IMAGE SENSOR DRIVING UNIT
104
ANALOG PROCESSING UNIT
105
A / D CONVERSION UNIT
106
TIMING GENERATOR
107
DRAM
108
DIGITAL SIGNAL PROCESSING UNIT
109
CPU
110
OPERATION UNIT
111
DISPLAY UNIT
112
MEDIA
113
ROM

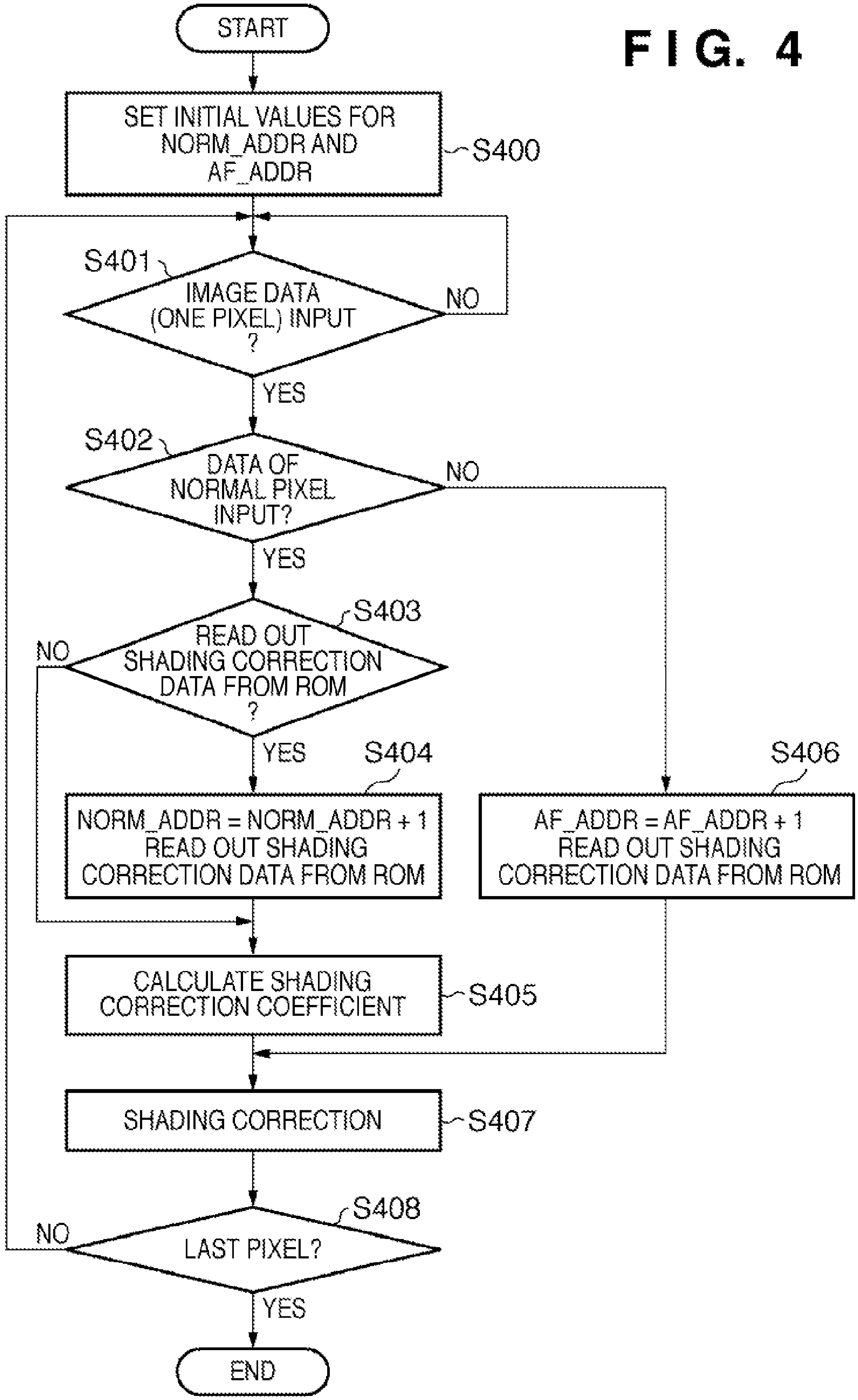


DISPLAY UNIT
111
MEDIA
112
ROM
113
DRAM
107
DIGITAL SIGNAL PROCESSING UNIT
108
IMAGE PROCESSING UNIT
203
ROM ADDRESS GENERATION UNIT
202
SHADING CORRECTION UNIT
200
SHADING CORRECTION COEFFICIENT GENERATION UNIT
201
CPU
109
A / D CONVERSION UNIT
105
TIMING GENERATOR
106

FIG. 2

FIG. 3

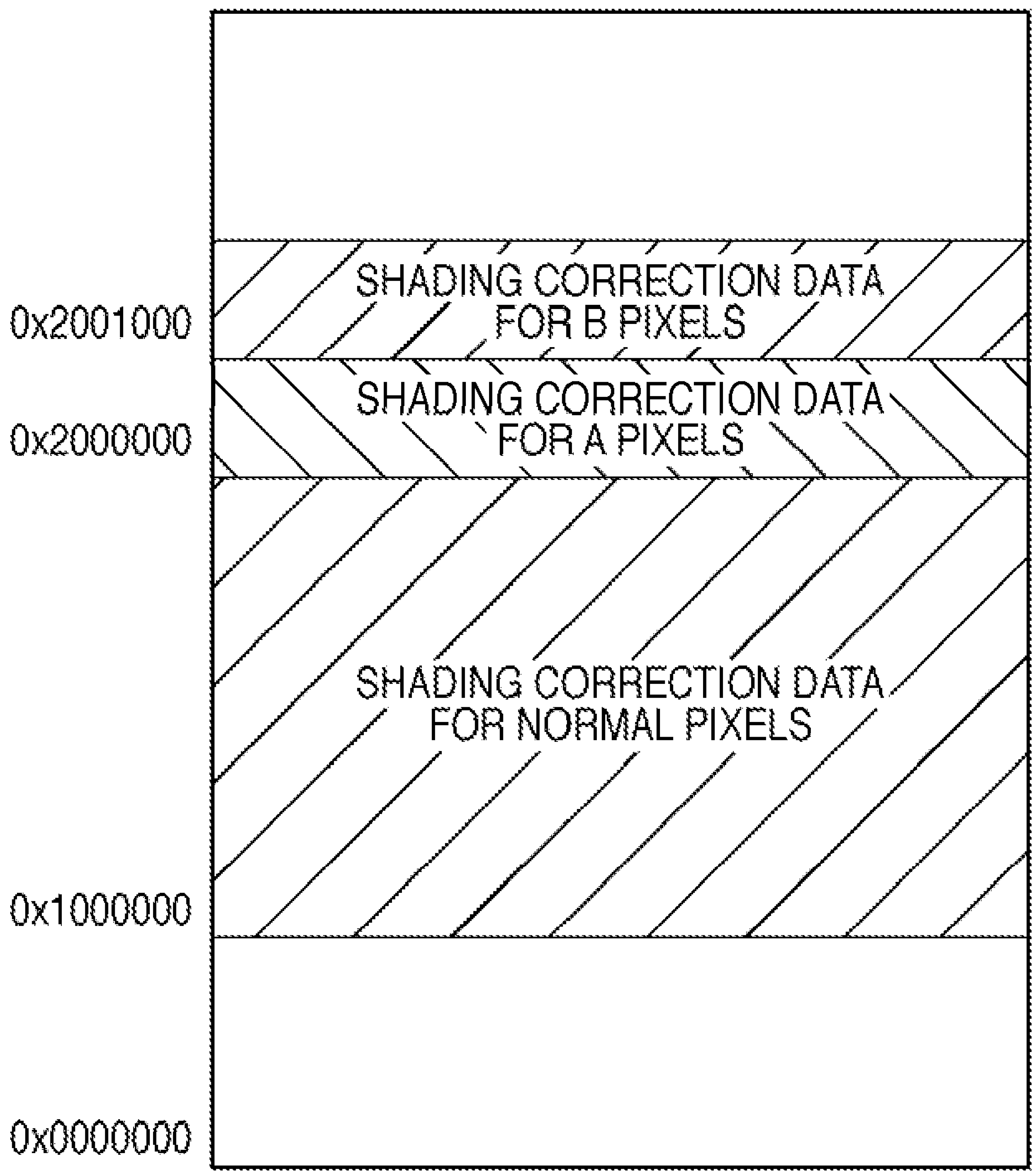

SHADING CORRECTION DATA FOR FOCUS DETECTION PIXELS
0x2000000
SHADING CORRECTION DATA FOR NORMAL PIXELS
0x1000000
0x0000000



START
SET INITIAL VALUES FOR NORM_ADDR AND AF_ADDR
S400
S401
IMAGE DATA (ONE PIXEL) INPUT ?
NO
YES
S402
DATA OF NORMAL PIXEL INPUT?
NO
YES
S403
READ OUT SHADING CORRECTION DATA FROM ROM ?
NO
YES
S404
NORM_ADDR = NORM_ADDR + 1 READ OUT SHADING CORRECTION DATA FROM ROM
S406
AF_ADDR = AF_ADDR + 1 READ OUT SHADING CORRECTION DATA FROM ROM
CALCULATE SHADING CORRECTION COEFFICIENT
S405
SHADING CORRECTION
S407
S408
LAST PIXEL?
NO
YES
END

FIG. 4

FIG. 5


SHADING CORRECTION DATA FOR B PIXELS
0x2001000
SHADING CORRECTION DATA FOR A PIXELS
0x2000000
SHADING CORRECTION DATA FOR NORMAL PIXELS
0x1000000
0x0000000

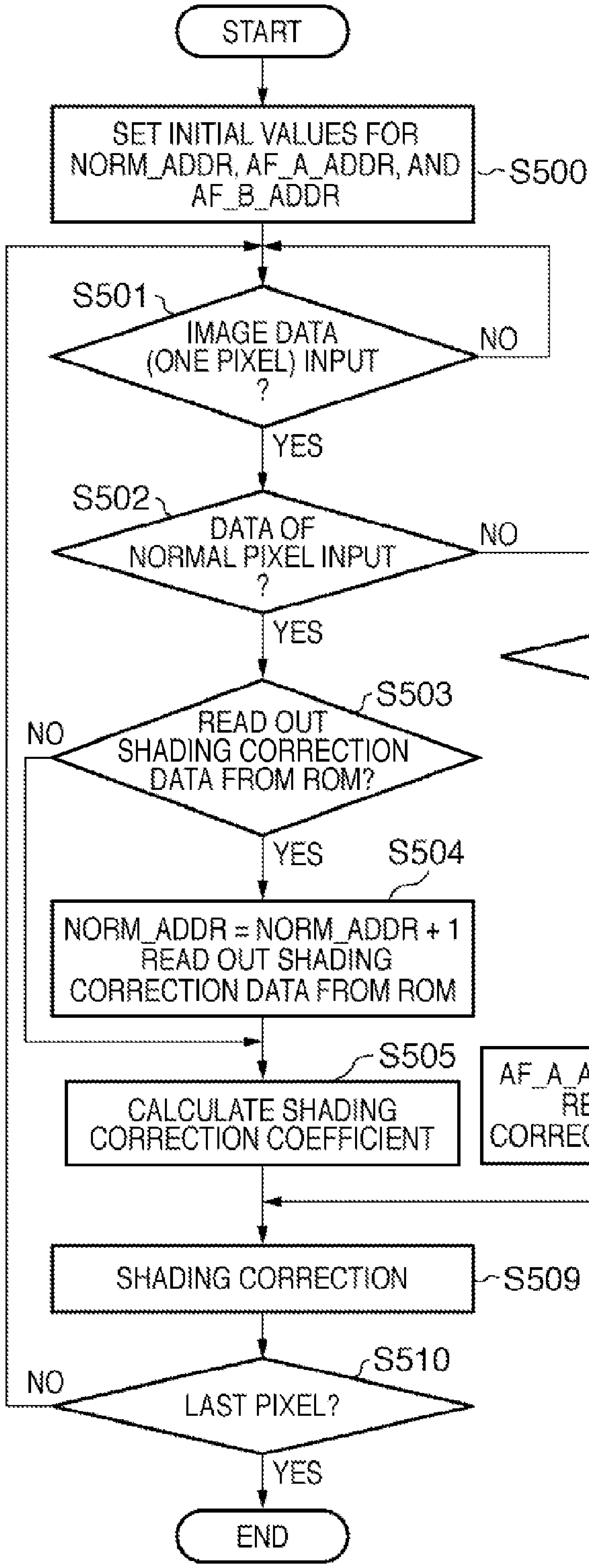

START
SET INITIAL VALUES FOR NORM_ADDR, AF_A_ADDR, AND AF_B_ADDR
S500
S501
IMAGE DATA (ONE PIXEL) INPUT ?
NO
YES
S502
DATA OF NORMAL PIXEL INPUT ?
NO
S506
A PIXEL?
NO
YES
S503
READ OUT SHADING CORRECTION DATA FROM ROM?
NO
YES
S504
NORM_ADDR = NORM_ADDR + 1 READ OUT SHADING CORRECTION DATA FROM ROM
S508
AF_B_ADDR = AF_B_ADDR + 1 READ OUT SHADING CORRECTION DATA FROM ROM
S507
AF_A_ADDR = AF_A_ADDR + 1 READ OUT SHADING CORRECTION DATA FROM ROM
S505
CALCULATE SHADING CORRECTION COEFFICIENT
SHADING CORRECTION
S509
S510
LAST PIXEL?
NO
YES
END

FIG. 6

FIG. 7

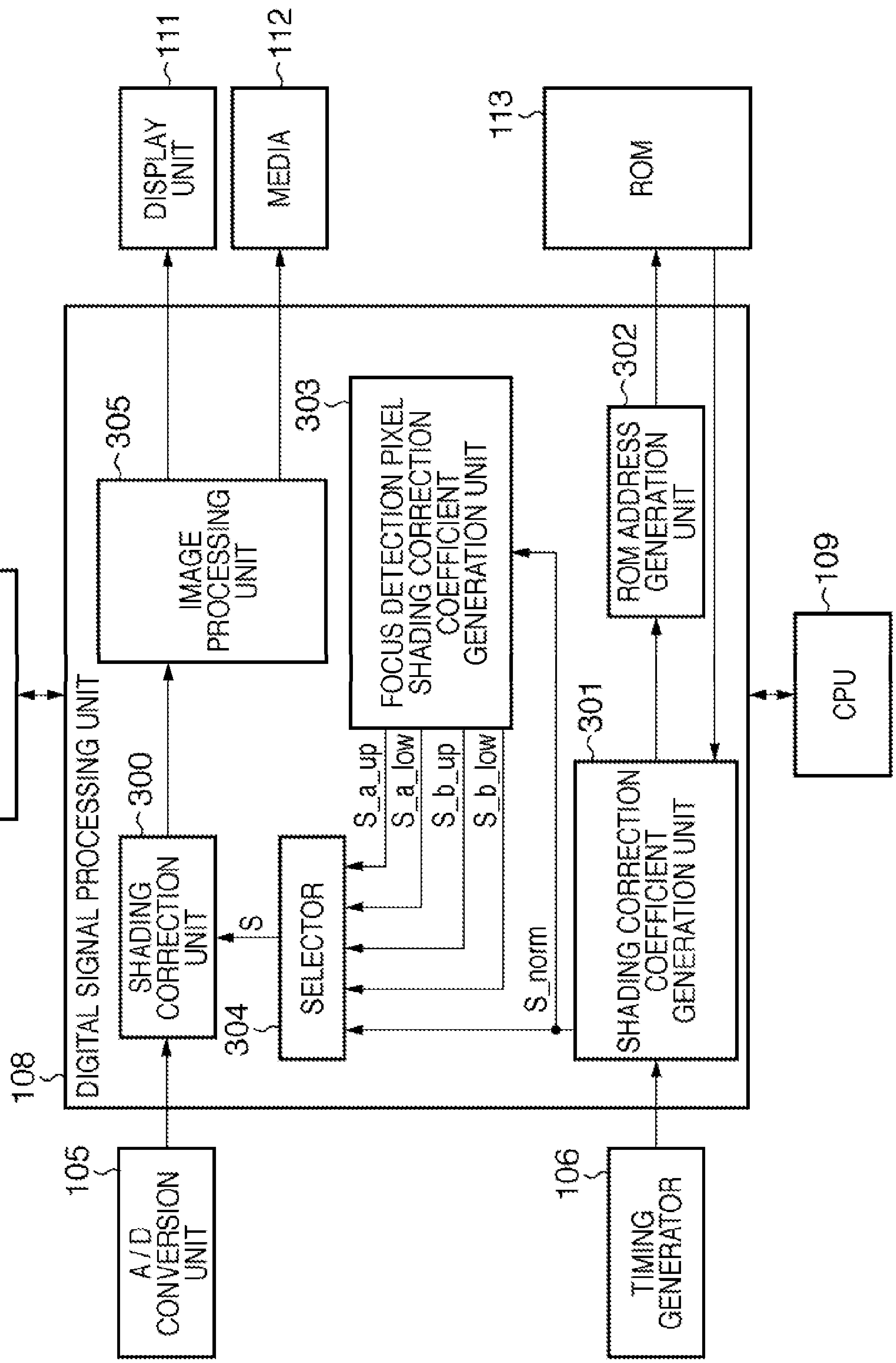

DISPLAY UNIT
111
MEDIA
112
ROM
113
DRAM
107
IMAGE PROCESSING UNIT
305
FOCUS DETECTION PIXEL SHADING CORRECTION COEFFICIENT GENERATION UNIT
303
ROM ADDRESS GENERATION UNIT
302
CPU
109
DIGITAL SIGNAL PROCESSING UNIT
108
SHADING CORRECTION UNIT
300
SELECTOR
304
S
S_a_up
S_a_low
S_b_up
S_b_low
S_norm
SHADING CORRECTION COEFFICIENT GENERATION UNIT
301
A / D CONVERSION UNIT
105
TIMING GENERATOR
106

FIG. 8

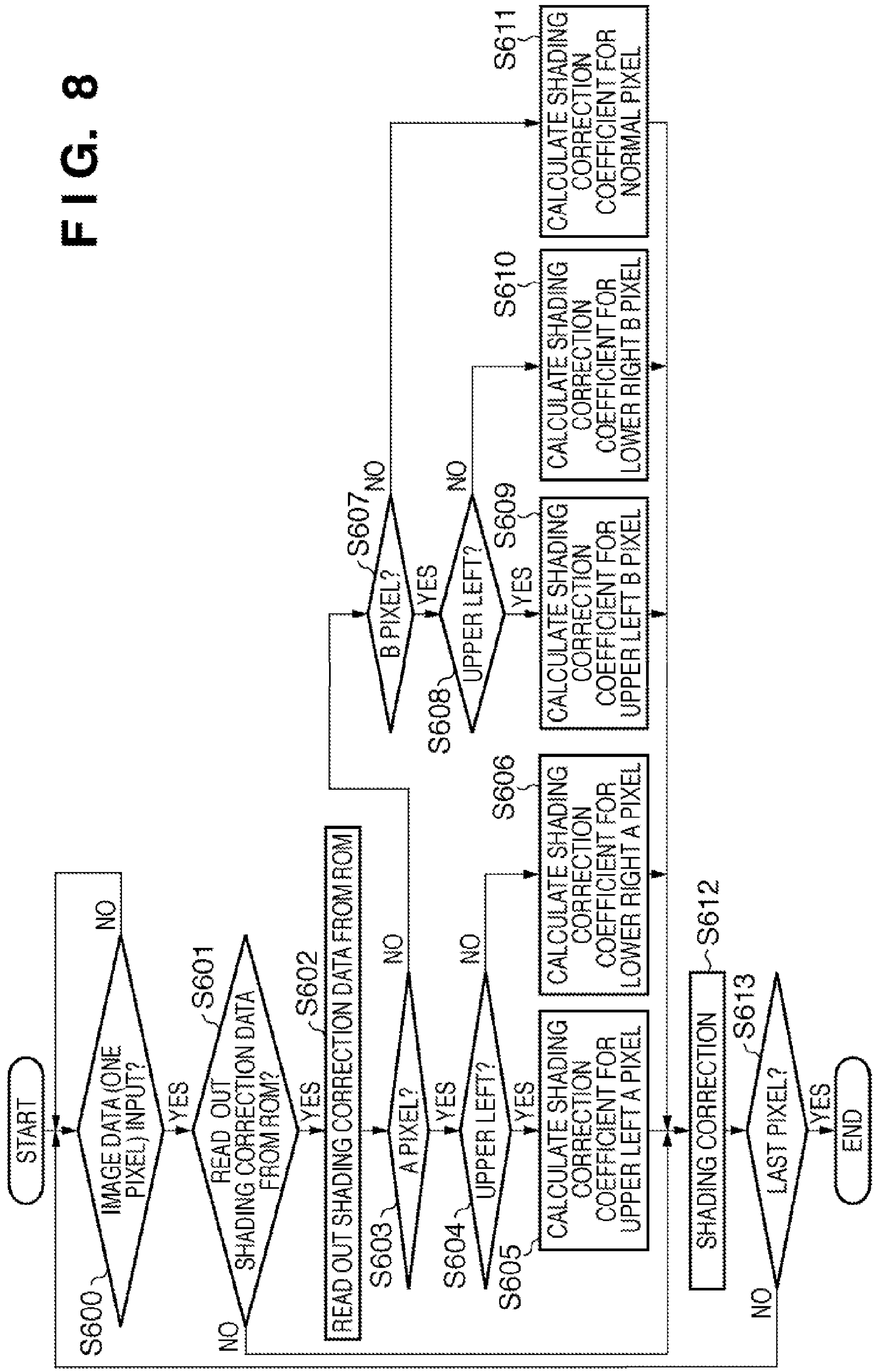

START
S600
IMAGE DATA (ONE PIXEL) INPUT?
YES
NO
S601
READ OUT SHADING CORRECTION DATA FROM ROM?
YES
NO
S602
READ OUT SHADING CORRECTION DATA FROM ROM
S603
A PIXEL?
YES
NO
S604
UPPER LEFT?
YES
NO
S605
CALCULATE SHADING CORRECTION COEFFICIENT FOR UPPER LEFT A PIXEL
S606
CALCULATE SHADING CORRECTION COEFFICIENT FOR LOWER RIGHT A PIXEL
S607
B PIXEL?
YES
NO
S608
UPPER LEFT?
YES
NO
S609
CALCULATE SHADING CORRECTION COEFFICIENT FOR UPPER LEFT B PIXEL
S610
CALCULATE SHADING CORRECTION COEFFICIENT FOR LOWER RIGHT B PIXEL
S611
CALCULATE SHADING CORRECTION COEFFICIENT FOR NORMAL PIXEL
S612
SHADING CORRECTION
S613
LAST PIXEL?
YES
NO
END

FIG. 9

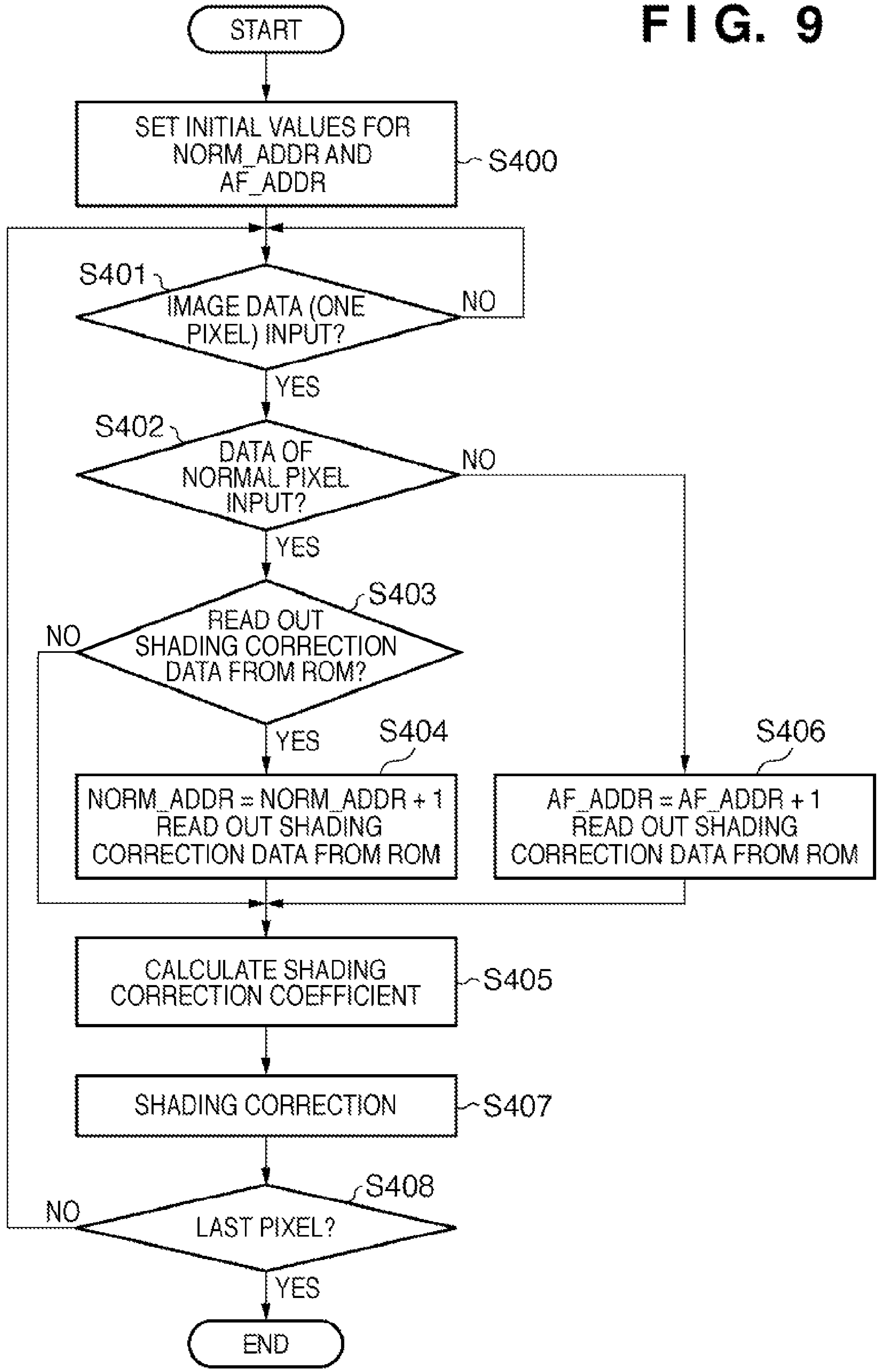

START
SET INITIAL VALUES FOR NORM_ADDR AND AF_ADDR
S400
S401
IMAGE DATA (ONE PIXEL) INPUT?
NO
YES
S402
DATA OF NORMAL PIXEL INPUT?
NO
YES
S403
READ OUT SHADING CORRECTION DATA FROM ROM?
NO
YES
S404
NORM_ADDR = NORM_ADDR + 1
READ OUT SHADING CORRECTION DATA FROM ROM
S406
AF_ADDR = AF_ADDR + 1
READ OUT SHADING CORRECTION DATA FROM ROM
CALCULATE SHADING CORRECTION COEFFICIENT
S405
SHADING CORRECTION
S407
S408
LAST PIXEL?
NO
YES
END

FIG. 10A

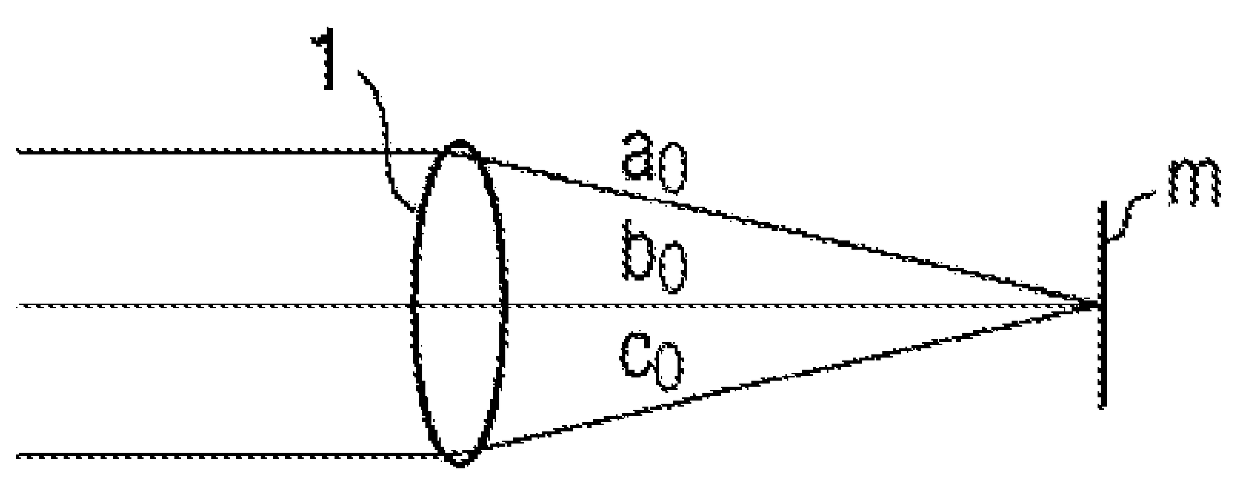


FIG. 10B

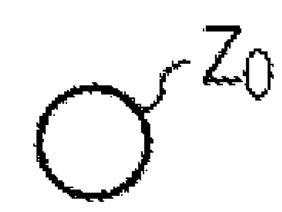


FIG. 11A

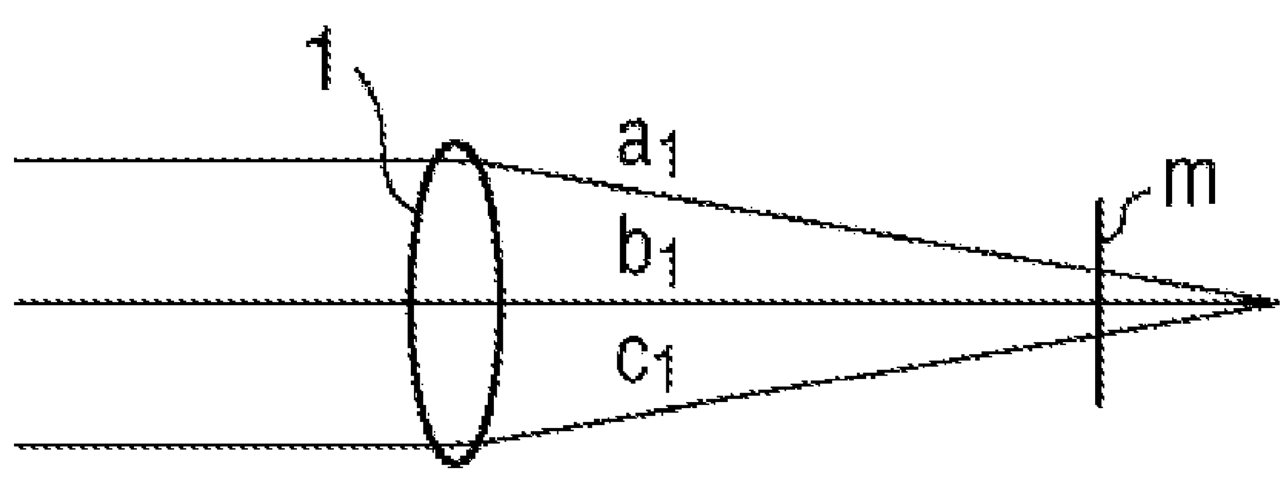


FIG. 11B

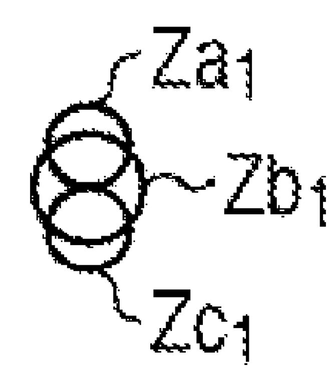


FIG. 12A

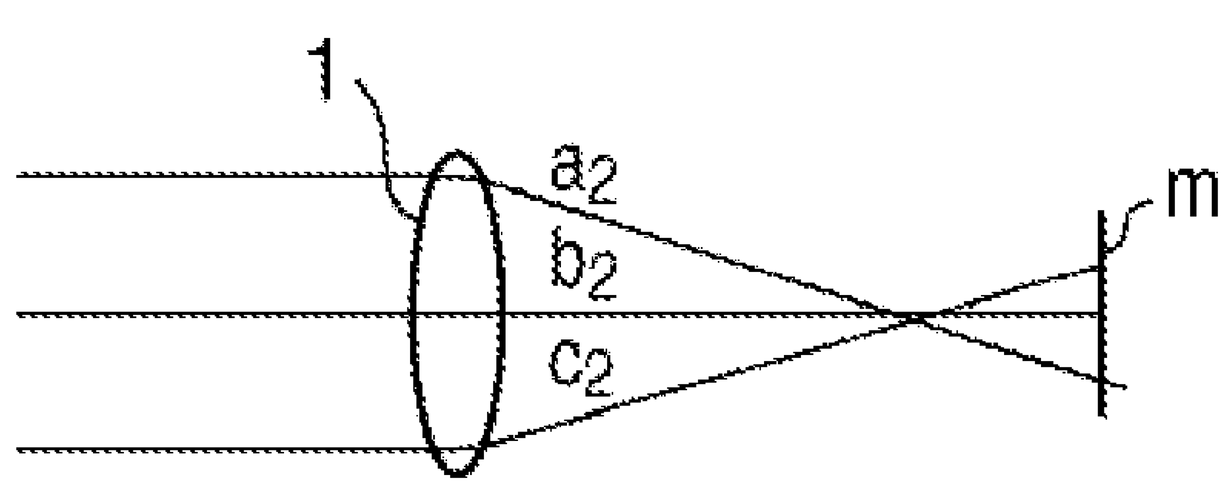


FIG. 12B

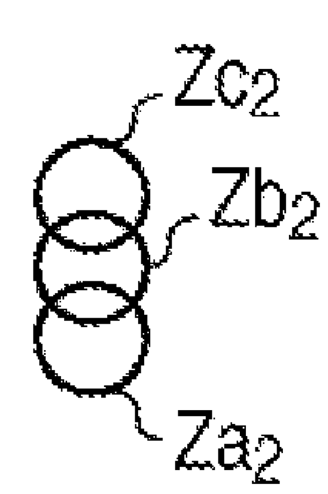
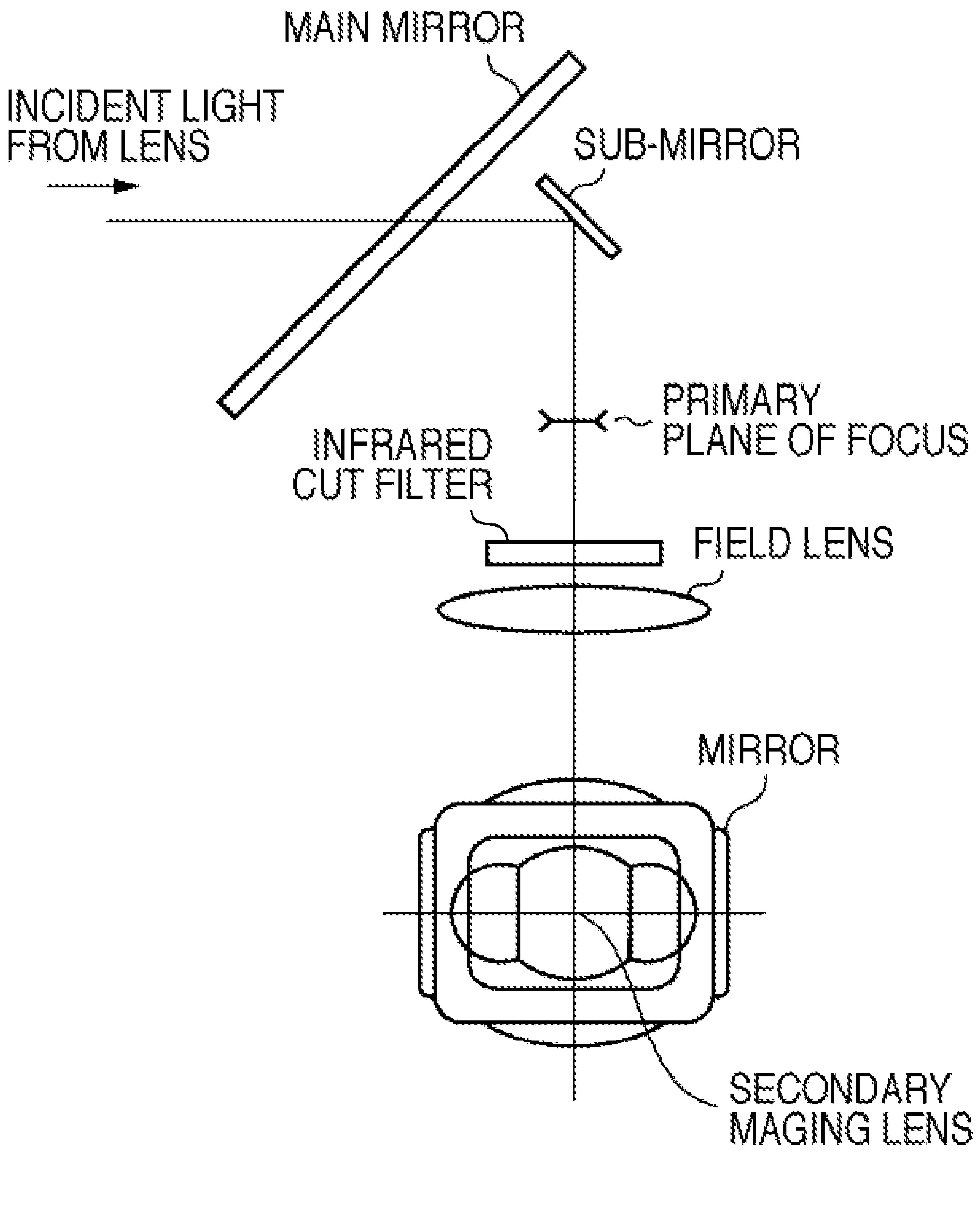
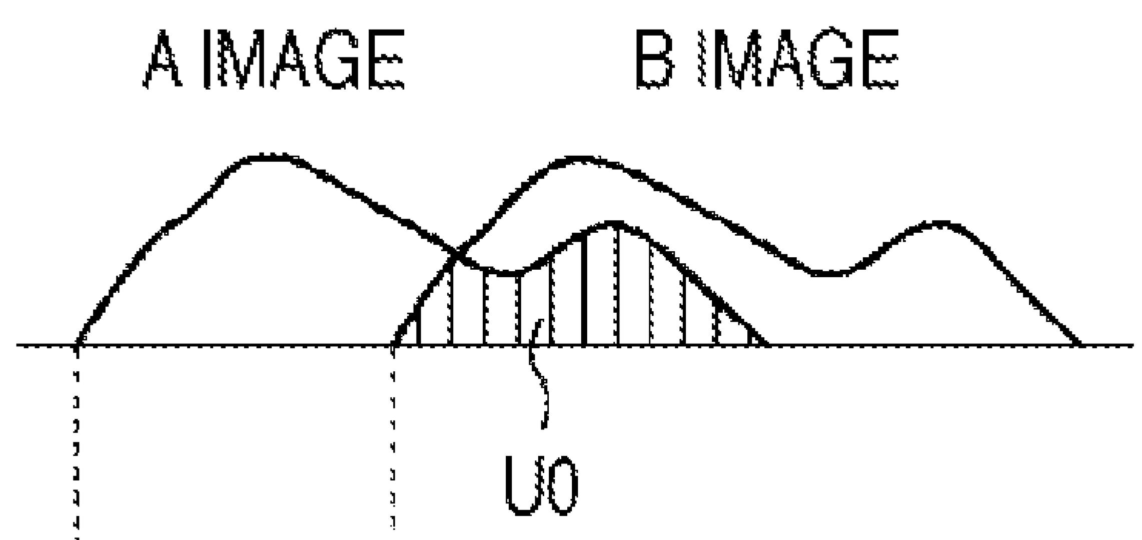


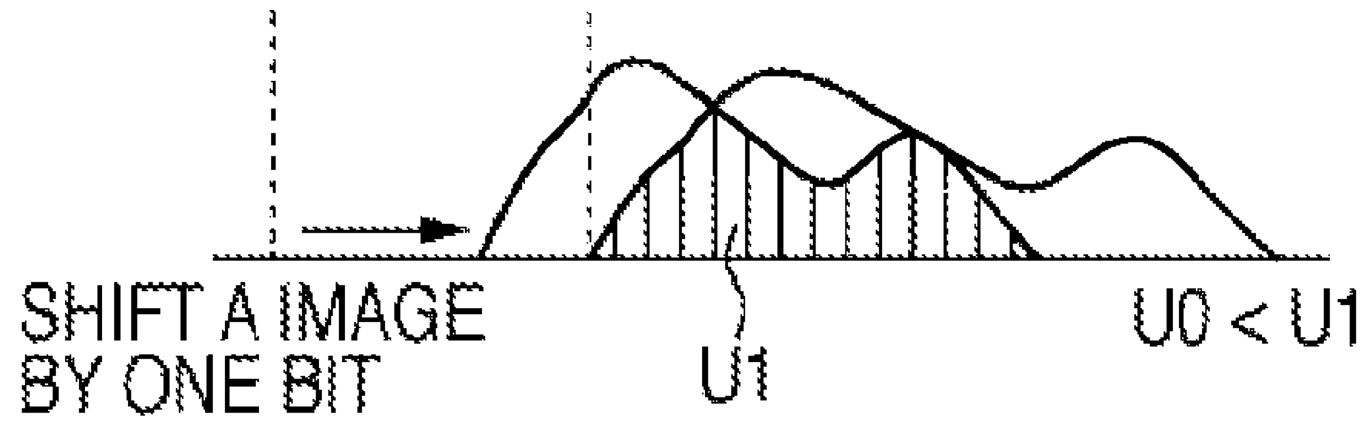
FIG. 13


MAIN MIRROR
INCIDENT LIGHT FROM LENS
SUB-MIRROR
PRIMARY PLANE OF FOCUS
INFRARED CUT FILTER
FIELD LENS
MIRROR
SECONDARY MAGING LENS

F I G. 14A



F I G. 14B



F I G. 14C

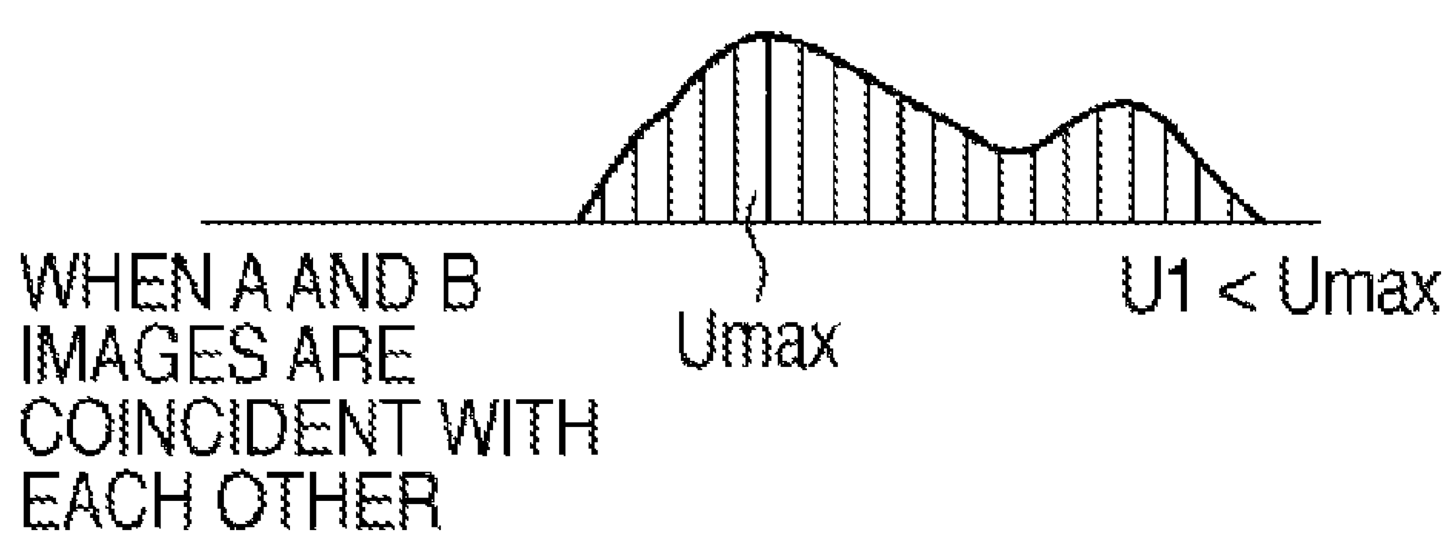
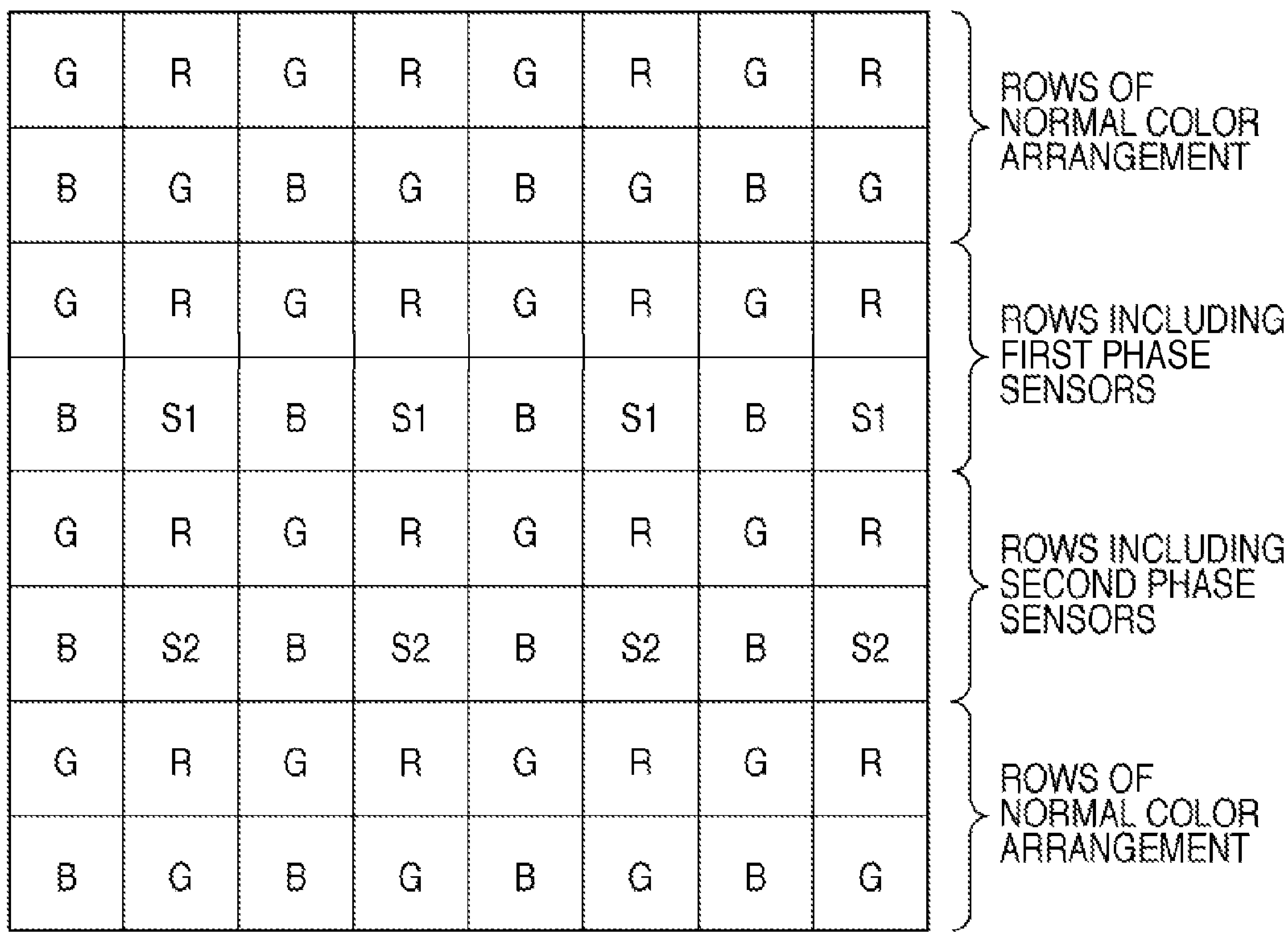


FIG. 15


G R G R G R G R
B G B G B G B G
G R G R G R G R
B S1 B S1 B S1 B S1
G R G R G R G R
B S2 B S2 B S2 B S2
G R G R G R G R
B G B G B G B G
ROWS OF NORMAL COLOR ARRANGEMENT
ROWS INCLUDING FIRST PHASE SENSORS
ROWS INCLUDING SECOND PHASE SENSORS
ROWS OF NORMAL COLOR ARRANGEMENT

F I G. 16

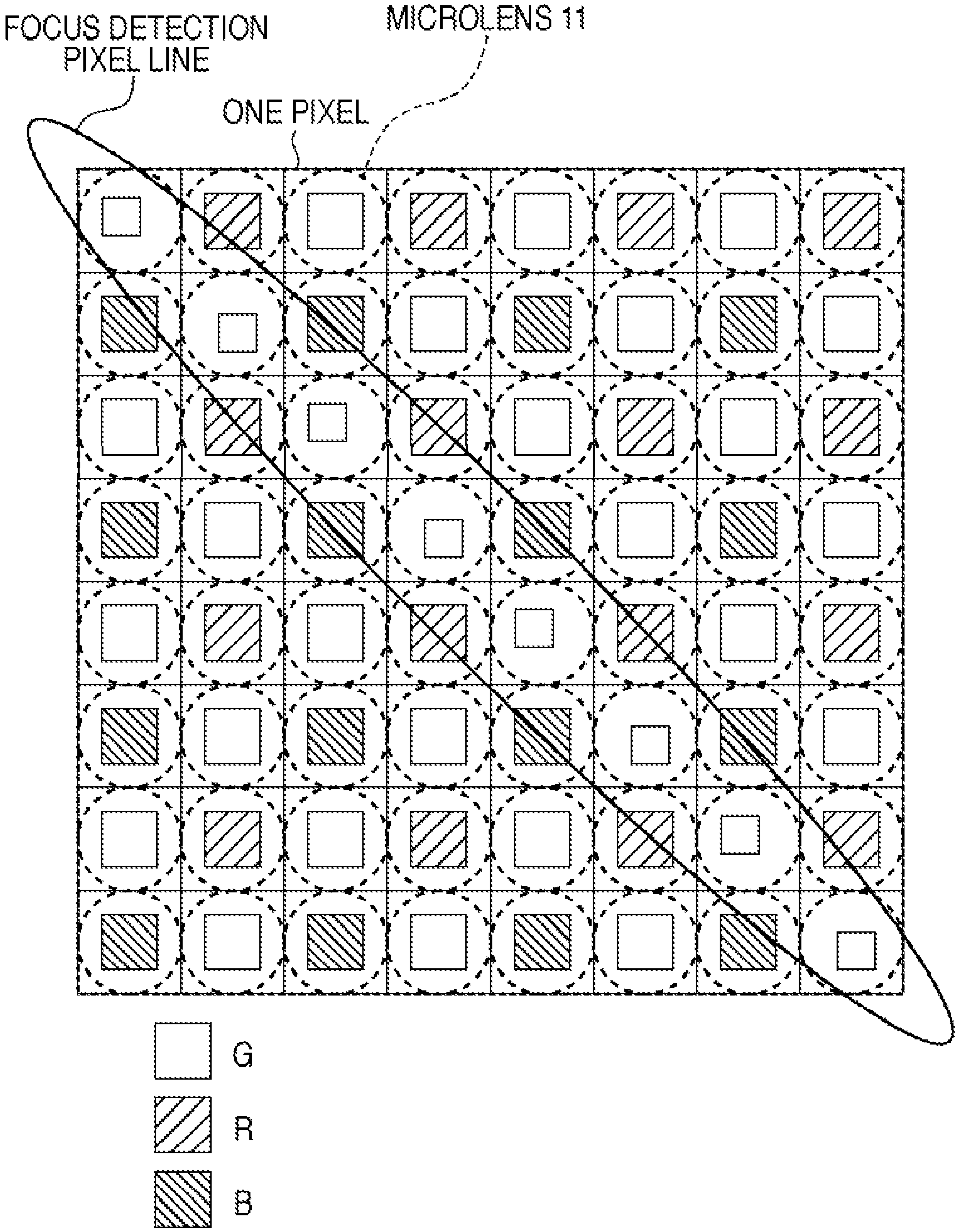


FIG. 17

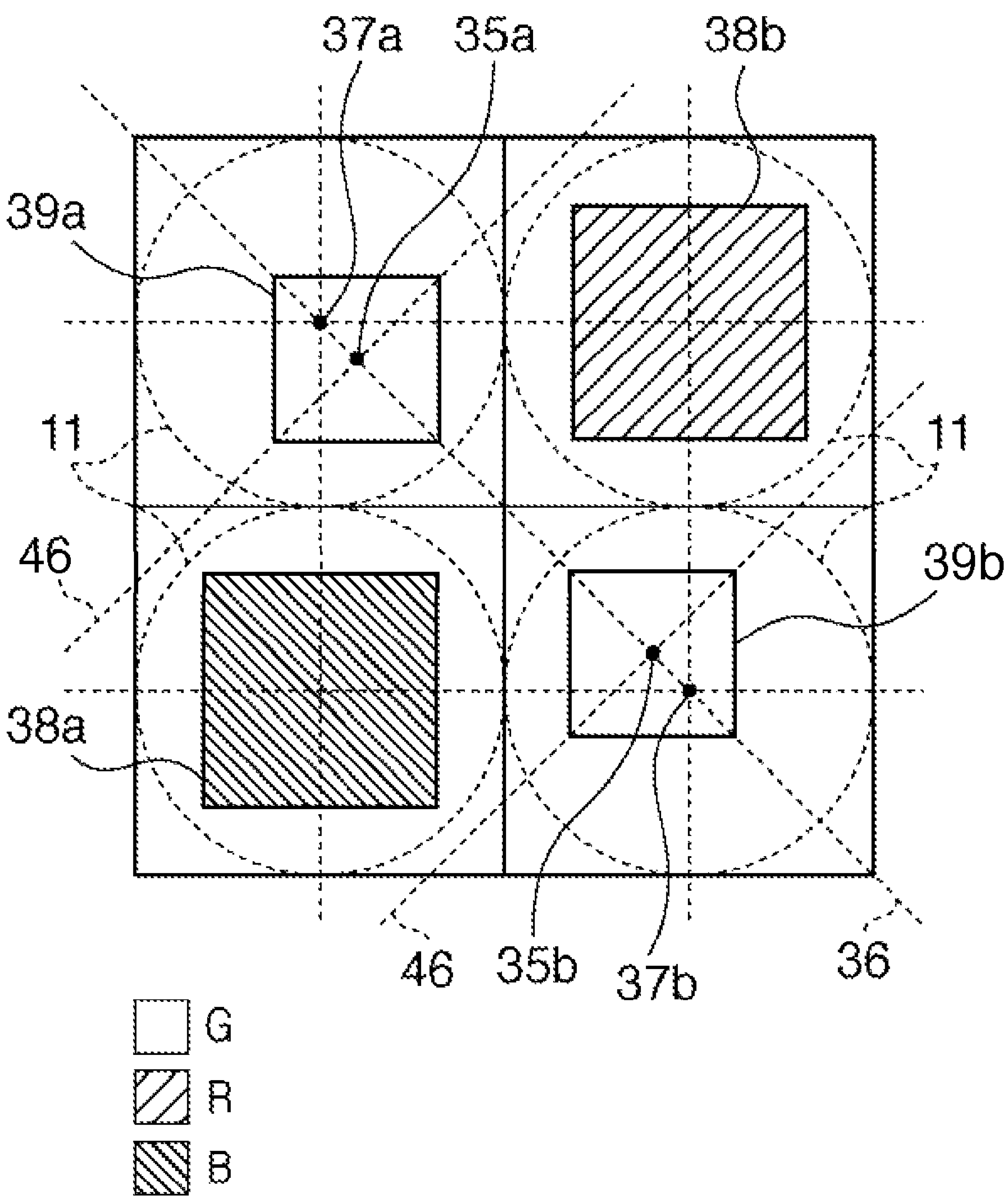


IMAGE CAPTURING APPARATUS AND IMAGE PROCESSING METHOD

This is a continuation of U.S. patent application Ser. No. 12/921,225, filed Sep. 7, 2010, which is a National Stage Entry of International Application No. PCT/JP2009/054981, filed Mar. 10, 2009.

TECHNICAL FIELD

The present invention relates to an image capturing apparatus and an image processing method, and more particularly, relates to an image capturing apparatus for carrying out focusing control based on image signals obtained from an image sensor, and an image processing method for the image signals.

BACKGROUND ART

Some image capturing apparatuses, such as digital cameras and digital video cameras, are configured to have an autofocusing mechanism for automatically carrying out focus control of a photographing lens and automatically bringing a subject into an in-focus state. The autofocusing mechanism is classified into a distance measurement method and a focus state detection method in terms of the principle of the in-focus method used. In the distance measurement method, the distance to a subject is measured, and the lens position is controlled depending on the measured distance. In the focus state detection method, the focus is detected at an image pickup surface, and the lens position is controlled to an in-focus position. Typical focus state detection methods include a contrast detection method, a phase difference detection method, etc., and the principle of the focus state detection method is disclosed in Japanese Patent Laid-Open No. 4-267211, for example.

Now, the focus state detection method will be described with reference to FIG. **10**A through FIG. **12**B. For example, in an in-focus state, light a_0, b_0, and c_0 passing through respective portions of a photographing lens **1** is converged onto an image pickup surface m as shown in FIG. **10**A to obtain an in-focus image Z_0 on the image pickup surface m as shown in FIG. **10**B.

A so-called rear focused state is shown in FIGS. **11**A and **11**B, in which the focal position is shifted rearward from the in-focus state shown in FIGS. **10**A and **10**B. Light a_1, b_1, and c_1 passing through respective portions of the photographing lens **1** is converged behind the image pickup surface m as shown in FIG. **11**A, thereby respectively resulting in separate images Za_1, Zb_1, and Zc_1 on the image pickup surface m as shown in FIG. **11**B.

In addition, a so-called front focused state is shown in FIGS. **12**A and **12**B. Light a_2, b_2, and c_2 passing through respective portions of the photographing lens **1** is converged in front of the image pickup surface m as shown in FIG. **12**A, thereby respectively resulting in separate images Za_2, Zb_2, and Zc_2 on the image pickup surface m as shown in FIG. **12**B.

As can be seen from FIGS. **11**A through **12**B, the front focused state and the rear focused state are opposite to each other in the image defocus direction, and the defocus direction and defocus amount are referred to as a so-called defocus amount. Since the relation between the defocus amount and an amount of driving of the focus lens to an in-focus position is determined by the optical system, autofocus control can be carried out by moving the focus lens to the in-focus position.

The processing for calculation of the defocus amount in the phase difference detection method is disclosed in Japanese Patent Laid-Open. No. 9-43507 as a known "MIN algorithm". FIG. **13** illustrates the internal configuration of a typical camera for detecting a correlation of phase differences by the MIN algorithm. Light incident from a lens is reflected downward of the camera by a sub-mirror mounted behind a main mirror mounted and inclined at 45 degrees. Then, the light is separated into two images by a secondary imaging lens to enter AF sensors, not shown. Then, the output data from these two AF sensors is loaded to obtain the correlation between the sensor outputs. Assuming that the respective sensor outputs are designated by a sensor **1** and a sensor **2**, the data of the sensor **1** is designated by A[1] to 1[n], and the data of the sensor **2** is designated by B[1] to B[n], the correlation U0 is expressed by the following formula (1) (FIG. **14**A).

$$U0 = \sum_{j=1}^{m} \min(A[j], B[j]) \tag{1}$$

(min(a,b) represents a smaller value of a and b)

First, U0 is calculated. Next, as shown in FIG. **14**B, the correlation U1 between the data obtained by shifting an A image by just one bit of the AF sensor and the data of a B image is calculated. U1 is expressed by the following formula 2.

$$U1 = \sum_{j=1}^{m} \min(A[j+1], B[j]) \tag{2}$$

(min(a,b) represents a smaller value of a and b)

In this way, correlations obtained by shifting by one bit are calculated one after another. If the two images are coincident with each other, the correlation reaches a maximum (FIG. **14**C). Thus, the shift amount and direction are obtained for the maximum value. This value corresponds to the defocus amount.

Meanwhile, Japanese Patent Laid-Open No. 2000-156823 discloses, as a device for implementing the phase difference detection method, an image sensor which has a filter color arrangement as shown in FIG. **15** and two-dimensionally arranged photoelectric conversion cells for converting optical images into electrical signals. As shown in FIG. **15**, some of the photoelectric conversion cells are used as first phase sensors **S1** and second phase sensors **S2** for focus detection in accordance with the phase difference detection method, that is, for purposes other than the forming of image data. According to Japanese Patent Laid-Open No. 2000-156823, the imaging lens for the AF sensor, the secondary imaging lens for providing phase differences, etc., as shown in FIG. **13** are unnecessary, thereby allowing reduction in size of the image capturing apparatus and cost reduction.

Furthermore, Japanese Patent Laid-Open No. 2005-303409 discloses the shapes of focus detection pixels of image sensors. Japanese Patent Laid-Open No. 2005-303409 discloses an arrangement of image sensors as shown in FIG. **16**, which includes a basic pixel arrangement referred to as Bayer arrangement of green pixels, red pixels, and blue pixels. The diagonally upper left to lower right pixels of the image sensor serve as pixels for focus detection. The other pixels serve as pixels for generating image data.

FIG. **17** is a diagram illustrating in detail some of the focus detection pixels of the image sensor shown in FIG. **16**. This figure illustrates an enlarged view of four pixels composed of two focus detection pixels, one red pixel, and one blue pixel, for explaining the shapes of openings, where the upper left and lower right pixels correspond to the focus detection pixels (green pixels), the upper right pixel corresponds to the red pixel, and the lower left pixel corresponds to the blue pixel. Reference numeral **11** denotes a microlens disposed on top of each opening. Reference numerals **37***a* and **37***b* denote center positions of the microlenses **11** in the adjacent focus detection pixels. Reference **36** denotes a line connecting the centers of the microlenses in in-line adjacent focus detection pixels. Reference numerals **38***a* and **38***b* each denote openings of the normal blue pixel and red pixel, other than the focus detection pixels. Reference numerals **39***a* and **39***b* denote openings of the focus detection pixels, which each have the shape obtained by reducing openings of the normal green pixels with reduction centers **35***a* and **35***b* as the centers, where the reduction centers **35***a* and **35***b* correspond to points obtained by moving the center positions **37***a* and **37***b* of the green pixels along the line **36** in opposite directions to each other, and the openings **39***a* and **39***b* of the focus detection have reduced shapes with the reduction centers **35***a* and **35***b* as the centers. Therefore, the openings **39***a* and **39***b* of the adjacent pixels are offset in different directions. Furthermore, the openings **39***a* and **39***b* are symmetrically shaped with respect to lines **46** perpendicular to the line **36**.

Furthermore, in Japanese Patent Laid-Open No. 2002-131623, in the case of reading image data in an image sensor which has a plurality of photoelectric conversion units included in one pixel, the charges of the plurality of photoelectric conversion units are added and read out. Then, in the case of carrying out focus detection processing, the charges of the respective photoelectric conversion units are independently read out, and data corresponding to the read charges is used for focus detection processing in a phase difference detection method. In addition, focus detection with a high degree of accuracy is achieved by carrying out processing different from the image correction processing in the adding and reading processing as the image correction processing in the focus detection processing.

However, in Japanese Patent Laid-Open No. 2005-303409, the focus detection pixels of the image sensor are diagonally arranged from the upper left to the lower right of the image sensor, and have shapes and openings reduced more than those of the normal pixels with points offset from the centers of the microlens **11** as the centers. Therefore, the focus detection pixels are different from the normal pixels in aperture, and further different from the normal pixels in the amount of light obtained from the microlenses **11** due to the offset from the centers of the microlenses **11**.

Japanese Patent Laid-Open No. 2000-41179 discloses a shading correction method for correcting shading characteristics of decrease in the amount of light input through an optical lens with distance from the optical axis of the lens. A ray of light incident through a photographing lens to an image sensor includes, in addition to components incident vertically with respect to the image pickup surface, a lot of light components for imaging from oblique directions. Circles of confusion of light collected by microlenses arranged at the image pickup surface for respective pixels are not always formed uniformly in center sections of each pixel of the image sensor but are shifted from the pixel centers depending on the positions of each pixel. Therefore, even in a case in which a plane with a uniform illuminance is photographed, the amount of light received is decreased in light receiving portions disposed in a peripheral section of the image pickup surface of the image sensor, comparing to light receiving portions in a center section of the image pickup surface around the optical axis of the photographing lens. As a result, luminance shading in which the brightness is rendered uneven depending on the positions in the image pickup surface resulting in distortion of the brightness is caused in photographing signals output from the image sensor, thereby resulting in decrease in image quality.

For example, Japanese Patent Laid-Open No. 2000-324505 discloses, as a correction method for shading correction, a method in which a plurality of pieces of shading correction data depending on the photographing state is prepared in advance as table values depending on the state of the optical system for carrying out luminance shading correction, and then an appropriately selected table value is used to carry out correction in an image processing unit for generating image data. However, if the shading correction data is provided for all of the pixels of the image sensor, the data size will be very large that requires a large capacity of the flash ROM or memory, thereby increasing the cost. Therefore, Japanese Patent No. 03824237 proposes a method of generating shading correction data by calculation using multiplication by gains determined depending on the distance from the center of the image sensor to each pixel. In a case in which the shading correction data is partially provided to obtain shading correction data for each pixel by calculation as described above, the same calculation method as that for normal pixels is not able to be applied to focus detection pixels due to the characteristics of microlenses of, and the shape of openings of, the image sensor.

Moreover, Japanese Patent Laid-Open No. 2005-303409 fails to describe luminance shading correction for focus detection pixels. When shading correction is carried out with the use of a shading coefficient optimized for normal pixels, for focus detection pixels which have a different aperture from the normal pixels and have an opening shape offset from the centers of the microlens **11**, the accuracy of calculation of the defocus amount for phase difference detection can be affected.

Furthermore, in Japanese Patent Laid-Open No. 2002-131623, only peak-level luminance shading is applied as luminance shading for normal pixels. By contrast, for focus detection pixels, peak-level luminance shading and dark-level luminance shading are applied to carry out shading correction for rendering the distribution of the amount of light more uniform with a higher degree of accuracy, as compared with the normal pixels. However, when the different shading corrections are carried out for the normal pixels and the focus detection pixels as described above, generation of image data and processing for calculating the defocus amount are not able to be carried out at the same time. Therefore, this method has a problem that a relatively long period of time is required until the defocus amount is calculated.

DISCLOSURE OF INVENTION

The present invention has been made in consideration of the above situation, and has as its object to enable focus detection with a higher degree of accuracy to be carried out with the use of focus detection pixels that receive pupil-divided light through openings that are offset from the optical axes of microlenses.

According to the present invention, the foregoing object is attained by providing an image capturing apparatus comprising: an image sensor for collecting via a microlens light incident through an optical system to capture an image, and comprising an imaging pixel for receiving light through an opening with a center position coincident with the optical axis of a microlens, a first focus detection pixel for receiving pupil-divided light through a first opening offset in a first direction from the optical axis of a microlens, and a second focus detection pixel for receiving pupil-divided light through a second opening offset in a second direction different from the first direction from the optical axis of a microlens; storage means for storing correction data for carrying out shading correction; correction coefficient generation means for generating a shading correction coefficient for the imaging pixel and shading correction coefficients for the first and second focus detection pixels from correction data stored in the storage means; and correction means for subjecting a signal of the imaging pixel to shading correction with the use of the shading correction coefficient for the imaging pixel, and subjecting signals of the first and second focus detection pixels to shading correction with the use of the shading correction coefficients for the first and second focus detection pixels.

According to the present invention, the foregoing object is also attained by providing an image processing method for pixel signals output from an image sensor for collecting via a microlens light incident through an optical system to capture an image, the image sensor comprising an imaging pixel for receiving light through an opening with a center position coincident with the optical axis of a microlens, a first focus detection pixel for receiving pupil-divided light through a first opening offset in a first direction from the optical axis of a microlens, and a second focus detection pixel for receiving pupil-divided light through a second opening offset in a second direction different from the first direction from the optical axis of a microlens, the method comprising: a step of reading out from storage means correction data for the imaging pixel for carrying out shading correction of the imaging pixel, or correction data for focus detection pixels for carrying out shading correction of the first and second focus correction pixels, which is stored in the storage means in advance, depending on a pixel intended for shading correction; a correction coefficient generation step of generating a shading correction coefficient for the imaging pixel or shading correction coefficients for the first and second focus detection pixels from the correction data read out from the storage means, depending on the pixel intended for shading correction; and a correction step of subjecting a signal of the imaging pixel to shading correction with the use of the shading correction coefficient for the imaging pixel, and subjecting signals of the first and second focus detection pixels to shading correction with the use of the shading correction coefficients for the first and second focus detection pixels.

Further features of the present invention will become apparent from the following description of exemplary embodiments (with reference to the attached drawings).

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a block diagram schematically illustrating the functional configuration of a digital still camera according to first to fourth embodiments of the present invention;

FIG. **2** is a block diagram illustrating the detailed configuration of a digital signal processing unit according to the first, second, and fourth embodiments of the present invention;

FIG. **3** is a diagram illustrating the memory structure of a ROM according to the first embodiment of the present invention;

FIG. **4** is a flowchart for explaining a shading correction processing according to the first embodiment of the present invention;

FIG. **5** is a diagram illustrating the memory structure of a ROM according to the second preferred embodiment of the present invention;

FIG. **6** is a flowchart for explaining a shading correction processing according to the second embodiment of the present invention;

FIG. **7** is a block diagram illustrating the detailed configuration of a digital signal processing unit according to the third embodiment of the present invention;

FIG. **8** is a flowchart for explaining a shading correction processing according to the third embodiment of the present invention;

FIG. **9** is a flowchart for explaining a shading correction processing according to the fourth embodiment of the present invention;

FIGS. **10**A and **10**B are diagrams for explaining a focus state detection method;

FIGS. **11**A and **11**B are diagrams for explaining a focus state detection method;

FIGS. **12**A and **12**B are diagrams for explaining a focus state detection method;

FIG. **13** is a diagram illustrating the internal configuration of a typical camera for detecting a phase difference;

FIGS. **14**A to **14**C are diagrams for explaining correlation calculation;

FIG. **15** is a diagram illustrating the configuration of an image sensor for carrying out a phase difference detection method;

FIG. **16** is a diagram illustrating the shape of focus detection pixels of an image sensor; and

FIG. **17** is a diagram illustrating in detail some of the focus detection pixels of the image sensor shown in FIG. **16**.

BEST MODE FOR CARRYING OUT THE INVENTION

Preferred embodiments of the present invention will be described in detail in accordance with the accompanying drawings.

First Embodiment

FIG. **1** is a block diagram schematically illustrating an example of the functional configuration of a typical digital still camera according to a first preferred embodiment of the present invention.

Reference numeral **100** denotes an optical system for capturing a subject image, which includes a photographing lens, a shutter, an aperture, etc. Furthermore, the photographing lens in the present embodiment is equipped with a zoom lens with a variable focal length. Reference numeral **101** denotes an image sensor, which is composed of, for example, CCDs (Charge Coupled Devices), CMOS sensors, or the like. Further, in the first embodiment, the image sensor **101** is composed of normal pixels (imaging pixels) intended to generate image data and focus detection pixels for use in focus detection. Reference numeral **102** denotes an optical system driving unit composed of an actuator for driving the optical system, which, for example, drives a lens of the optical system **100** during autofocusing. Reference numeral **103** denotes an image sensor driving unit, which generates horizontal and vertical transfer driving signals when the image sensor **101** is composed of, for example, CCDs or CMOS sensors.

Reference numeral **104** denotes an analog processing unit, which carries out correlated double sampling, not shown, for removing reset noises contained in input image signals, and gain variable amplification for amplifying the level of image signals by varying the gain. Reference numeral **105** denotes an A/D conversion unit for quantizing analog data output from the analog processing unit **104** into digital data. Reference numeral **108** denotes a digital signal processing unit for applying image processing to digital data output from the A/D conversion unit **105**. Typically, the digital signal processing unit **108** carries out white balance adjustment, gain adjustment, filtering, interpolation processing, etc., resizes the digital data to an appropriate image size, compresses the data, and records the compressed data on a media **112**. Alternatively, the digital signal processing unit **108** carries out processing for display on an LCD or the like of a display unit **111**. Furthermore, in the present embodiment, the digital signal processing unit **108** carries out shading correction processing.

Reference numeral **106** denotes a timing generator for generating and transmitting timing signals to the optical system driving unit **102**, the image sensor driving unit **103**, the analog processing unit **104**, the A/D conversion unit **105**, and the digital signal processing unit **108**. Reference numeral **107** denotes an external memory for buffering intermediate data in the process performed by the digital signal processing unit **108**. Reference numeral **109** denotes a CPU for controlling the entire camera. Reference numeral **110** denotes an operation unit such as a switch operated by a user to control the camera. Reference numeral **113** denotes a ROM with instructions from the CPU **109**, etc., stored therein. In the present embodiment, the ROM **113** stores shading correction data for carrying out shading correction.

FIG. **2** is a block diagram illustrating in detail some functions of the digital signal processing unit **108** in FIG. **1**, for explaining operation of shading correction process.

Reference numeral **200** denotes a shading correction unit for carrying out shading correction. The shading correction unit **200** carries out calculation for shading correction, for image data read out from the normal pixels or signals for focus detection (focus detection data) read out from the focus detection pixels on the image sensor **101** and input from the A/D conversion unit **105**. Reference numeral **201** denotes a shading correction coefficient generation unit, which determines the position of a pixel of the image sensor **101** from a timing signal from the timing generator **106**, and generates a request signal for reading out shading correction data to a ROM address generation unit **202** described below. The request signal is transmitted as a signal that is able to determine whether shading correction data read out from the ROM **113** is intended for the normal pixels (photographing pixels) or the focus detection pixels. The shading correction coefficient generation unit **201**, in the case of the normal pixels, calculates a shading correction coefficient for each pixel from the shading correction data read out from the ROM **113**, and transmits the shading correction coefficients to the shading correction unit **200**. On the other hand, in the case of the focus detection pixels, the shading correction coefficient generation unit **201** transmits the read shading correction data as shading correction coefficients directly to the shading correction unit **200** without carrying out the calculation. Reference numeral **202** denotes the ROM address generation unit. The ROM address generation unit **202** determines, from the request signal generated by the shading correction coefficient generation unit **201**, whether data input into the shading correction unit **200** is intended for the normal pixels or the focus detection pixels, and reads out appropriate shading correction data from the ROM **113**.

Reference numeral **203** denotes an image processing unit for carrying out digital signal processing other than the shading correction processing. The processing carried out in the image processing unit **203** includes phase difference detection processing in which, for focus detection data subjected to shading correction, the maximum value of correlation calculated by "MIN algorithm" is obtained for each of pixels of different pupil positions, an A pixel and a B pixel. However, the phase difference detection processing may be carried out by the CPU **109**. The defocus amount obtained by the phase difference detection processing is transmitted by the CPU **109** to the optical system driving unit **102** to drive the zoom lens with autofocusing function in the optical system **100**.

FIG. **3** is a diagram illustrating a memory map for specifying only shading correction data in the ROM **113**. In the first embodiment, for physical addresses of the ROM **113**, the shading correction data for the normal pixels is stored in addresses from 0x1000000 to 0x1FFFFFF. Further, the shading correction data for the focus detection pixels is stored in addresses from 0x2000000 to 0x200FFFF. The shading correction data read for the addresses, for use in the normal pixels, is data intended for a portion of the image sensor **101**, and the shading correction coefficient for each pixel is calculated in the shading correction coefficient generation unit. On the other hand, for each of the focus detection pixels there is held data as the shading correction coefficient.

The ROM address generation unit **202** issues the address of 0x1000000 to the ROM **113** in a case in which a request signal generated by the shading correction coefficient generation unit **201** is determined for a normal pixel. The shading correction data for the normal pixel, which has been read from the ROM **113**, is used to calculate a shading correction coefficient in the shading correction coefficient generation unit **201**. The shading correction coefficient is then transmitted to the shading correction unit **200**, and shading correction is applied to image data of the normal pixel input from the A/D conversion unit **105**.

When the timing generator **106** transmits the next timing signal to the digital signal processing unit **108**, the shading correction coefficient generation unit **201** generates a request signal from the address of the next image sensor position, and transmits the request signal to the ROM address generation unit **202**. When this request signal is determined to be for a focus detection pixel, the ROM address generation unit **202** stores the address value of the previous normal pixel, and issues the address of 0x2000000 for the focus detection pixel to the ROM **113**. The shading correction data for the focus detection pixel, which has been read from the ROM **113**, is transmitted as a shading correction coefficient from the shading correction coefficient generation unit **201** directly to the shading correction unit **200**, and shading correction is applied to focus detection data of the focus detection pixel input from the A/D conversion unit **105**.

By contrast, if the address value of the image sensor position at the next timing signal is determined to be for a normal pixel, the ROM address generation unit **202** stores the address value of the previous focus detection pixel. Then, 1 is added to the stored address value to obtain the address value of the next normal pixel, and the address 0x1000001 is issued to the ROM **113**. Similarly, in a case in which the next timing signal is determined to be for the focus detection pixel, the address value 0x1000001 of the previous normal pixel is stored, and the address 0x2000001, which is an address value obtained by adding 1 to the address value of the previous focus detection pixel, is issued to the ROM **113**.

Next, shading correction processing in the first embodiment will be described with reference to a flowchart of FIG. **4**. It is to be noted that in FIG. **4**, the term NORM_ADDR refers to an address value of the ROM **113** with shading correction data stored therein for a normal pixel that is next subjected to processing in the shading correction unit **200** of the digital signal processing unit **108**, the term AF_ADDR refers to an address value of the ROM **113** with shading correction data stored therein for a focus detection pixel that is next subjected to processing in the shading correction unit **200** of the digital signal processing unit **108**, and the term ROM_ADDR refers to an actual address value output to the ROM **113**.

In step S**400**, initial values are assigned to the NORM_ADDR and the AF_ADDR. In the memory map example of FIG. **3**, the address 0x1000000 and the address 0x2000000 are respectively assigned to the NORM_ADDR and the AF_ADDR.

In step S**401**, it is determined if image data (of one pixel) is input. When it is determined that the image data is input in step S401 ("YES" in step S**401**), the processing proceeds to step S**402**.

In step S**402**, it is determined if the input image data is image data of a normal pixel or focus detection data of a focus detection pixel.

When it is determined that the image data is of a normal pixel in step S**402** ("YES" in step S**402**), it is determined in step S**403** whether shading correction data is to be read out from the ROM **113**.

When in step S**403** it is determined that shading correction data is to be read out from the ROM **113**, the processing moves to step S**404**. In step S**404**, the normal pixel address NORM_ADDR is increased by 1, and an address value obtained by increasing the normal pixel address NORM_ADDR by 1 is set as the ROM_ADDR. Then, based on the ROM_ADDR, shading correction data for the normal pixel is read out from the ROM **113**.

On the other hand, when it is determined in step S**403** that no shading correction data is to be read out from the ROM **113**, the processing proceeds directly to step S**405** without reading out shading correction data form the ROM **113**.

In step S**405**, in a case in which the shading correction data for the normal pixel is read out from the ROM **113** in step S**404**, a shading correction coefficient is calculated from the read shading correction data for the normal pixel. In a case in which the shading correction data is not read out from the ROM **113**, the shading correction coefficient is calculated based on the shading correction data for the normal pixel read out up to then and on the position of the normal pixel.

On the other hand, when it is determined that the image data is of a focus detection pixel in step S**402** ("NO" in step S**402**), the processing proceeds to step S**406**. In step S**406**, the focus detection pixel address AF_ADDR is increased by 1, and an address value obtained by increasing the focus detection pixel address AF_ADDR by 1 is set as the ROM_ADDR. Then, based on the ROM_ADDR, shading correction data for the focus detection pixel is read out from the ROM **113**, and the processing proceeds to step S**407**.

In step S**407**, in the case of the normal pixel, shading correction is carried out in accordance with the shading correction coefficient calculated in step S**405**. Alternatively, in the case of the focus detection pixel, shading correction is carried out in accordance with the shading correction data for the focus detection pixel (shading correction coefficient) read out from the ROM **113**.

In step S**408**, it is determined if the image data subjected to the shading correction processing in step S**407** corresponds to the last pixel read out from the image sensor **101**. If the image data corresponds to the last pixel ("YES" in step S**408**), the processing is completed. If not ("NO" in step S**408**), the processing returns to step S**401**, and again moves to determining if the next image data is input.

In the first embodiment, it is possible to carry out focus detection with a high degree of accuracy by carrying out appropriate shading correction for the focus detection pixels. Furthermore, it is possible to speed up focus detection since generation of normal image data and generation of data for focus detection can be processed in a period for which the image sensor is read out once.

It is to be noted that the shading correction coefficient is calculated from the shading correction data in step S**405** in the case of the normal pixels in the first embodiment. However, the shading correction coefficient may be used as-is without calculation as long as the system can store in the ROM **113** the shading correction coefficient for all of the normal pixels.

Second Embodiment

FIG. **16** shows an arrangement of an image sensor of normal pixels and focus detection pixels in a second embodiment. An enlarged view of a portion of the arrangement is shown in FIG. **17**. The upper left and lower right pixels in FIG. **17** are focus detection pixels. The center of microlenses **11** and the center of the opening of the normal pixels matches, while the center of the opening of the upper left pixel is offset downward and rightward as a first direction, and the center of the opening of the lower right pixel is offset upward and leftward as a second direction. The pixels each are focus detection pixels with different pupil positions as viewed from the optical system, where the upper left focus detection pixel is referred to as an A pixel, whereas the lower right focus detection pixel is referred to as a B pixel. Separate shading correction data is provided for each of the focus detection pixel, the A pixel and the B pixel.

The camera in the second embodiment has the same configuration as that shown in FIGS. **1** and **2** of the first embodiment described above. The second embodiment is different from the first embodiment in that shading correction data for the focus detection pixels to be stored in the ROM **113** is separately provided for the A pixel and the B pixel.

FIG. **5** is a diagram illustrating a memory map for specifying only shading correction data in the ROM **113**. In the second embodiment, for physical addresses of the ROM **113**, the shading correction data for the normal pixels is arranged in addresses from 0x1000000 to 0x1FFFFFF. The shading correction data for the A pixels as focus detection pixels is arranged in addresses from 0x2000000 to 0x2000FFF. The shading correction data for the B pixels as focus detection pixels is arranged in addresses from 0x2001000 to 0x2001FFF.

Next, shading correction processing in the second embodiment is described with reference to a flowchart of FIG. **6**. It is to be noted that in FIG. **6**, the term NORM_ADDR refers to an address value of the ROM **113** with shading correction data stored therein for a normal pixel that is next subjected to processing in the shading correction unit **200** of the digital signal processing unit **108**, the term AF_A_ADDR refers to an address value of the ROM **113** with shading correction data stored therein for the A pixel as a focus detection pixel that is next subjected to processing in the shading correction unit **200** of the digital signal processing unit **108**, the term AF_B_ADDR refers to an address value of the ROM **113** with shading correction data stored therein for the B pixel as a focus detection pixel that is next subjected to processing in the shading correction unit **200** of the digital signal processing unit **108**, and the term ROM_ADDR refers to an actual address value output to the ROM **113**.

In step S**500**, initial values are set for the NORM_ADDR, the AF_A_ADDR, and the AF_B_ADDR. In the memory map example of the ROM **113** in FIG. **5**, the address 0x1000000, the address 0x2000000, and the address 0x2001000 are respectively assigned to the NORM_ADDR, the AF_A_ADDR, and the AF_B_ADDR.

In step **S501**, it is determined if image data (of one pixel) is input. When it is determined that pixel data is input ("YES" in step **S501**), the processing proceeds to step **S502**.

In step **S502**, it is determined if the input image data is image data of a normal pixel or focus detection data of a focus detection pixel.

When it is determined that the image data is of a normal pixel in step **S502** ("YES" in step **S502**), it is determined in step **S503** whether shading correction data is to be read out from the ROM **113**.

When it is determined in step **S503** that shading correction data is to be read out from the ROM **113** ("YES" in step **S503**), the processing moves to step **S504**. In step **S504**, the normal pixel address NORM_ADDR is increased by 1, and an address value obtained by increasing the normal pixel address NORM_ADDR by 1 is set as the ROM_ADDR. Then, based on the ROM_ADDR, shading correction data for the normal pixel is read out from the ROM **113**.

In step **S505**, the shading correction coefficient for each pixel is calculated from the shading correction data for the normal pixel which has been read from the ROM **113**.

On the other hand, when it is determined that the image data is of a focus detection pixel in step **S502**, the processing proceeds to step **S506** and it is determined if the focus detection pixel is an A pixel. In a case in which it is determined that the focus detection pixel is an A pixel, the processing proceeds to step **S507** and the A pixel address AF_A_ADDR is increased by 1, and an address value obtained by increasing the A pixel address AF_A_ADDR by 1 is set as the ROM_ADDR. On the other hand, in a case in which it is determined in step **S506** that the focus detection pixel is an B pixel, the processing proceeds to step **S508** and the B pixel address AF_B_ADDR is increased by 1, and an address value obtained by increasing the B pixel address AF_B_ADDR by 1 is set as the ROM_ADDR. Then, in step **S507** or **S508**, based on the ROM_ADDR, shading correction data for the A pixel or the B pixel is read out from the ROM **113**.

In step **S509**, in the case of the normal pixel, shading correction is carried out in accordance with the shading correction coefficient calculated in step **S505**. Alternatively, in the case of the A pixel or the B pixel as a focus detection pixel, shading correction is carried out in accordance with the shading correction data for the focus detection pixel which has been read out from the ROM **113**.

In step **S510**, it is determined if the image data subjected to the shading correction processing in step **S509** corresponds to the last pixel read out from the image sensor **101**. If the image data corresponds to the last pixel ("YES" in step **S510**), the processing is completed. If not ("NO" in step **S510**), the processing returns to step **S501**, and again moves to determining if the next image data is input.

Third Embodiment

The third embodiment provides, as compared to the first embodiment, a method in which shading correction data for focus detection is calculated from shading correction data for a normal pixel. The camera according to the third embodiment has the same configuration as that in FIG. **1** of the first embodiment.

FIG. **7** is a block diagram illustrating in detail some functions of a digital signal processing unit **108** in the third embodiment. Processing is described below with reference to FIG. **7**, in which a shading correction coefficient for a focus detection pixel is calculated from shading correction data for a normal pixel.

Reference numeral **300** denotes a shading correction unit for carrying out shading correction. The shading correction unit **300** carries out calculation for shading correction, for image data read out from the normal pixels or signals for focus detection (focus detection data) read out from the focus detection pixels on the image sensor **101** and input from an A/D conversion unit **105**. Reference numeral **301** denotes a shading correction coefficient generation unit, which determines the position of a pixel of the image sensor **101** from a timing signal from a timing generator **106**, and then generates a request signal for reading out shading correction data to a ROM address generation unit **302** described below. The request signal is transmitted as a signal indicating that all of shading correction data read from the ROM **113** is intended for normal pixels.

Reference numeral **302** denotes the ROM address generation unit. The ROM address generation unit **302** reads out shading correction data from the ROM **113**, based on the request signal generated by the shading correction coefficient generation unit **301**. The shading correction data for addresses read out at this point includes only data for some pixels of the image sensor **101**. In addition, the read shading correction data corresponds to shading correction data for normal pixels. Accordingly, even if the image data input from the A/D conversion unit **105** is data from a focus detection pixel, shading correction data optimized for a normal pixel will be read out from the ROM **113**.

The shading correction coefficient generation unit **301** calculates a shading correction coefficient S_norm for a normal pixel from the shading correction data read out from the ROM **113**, and transmits the shading correction coefficient S_norm to a focus detection pixel shading correction coefficient generation unit **303** and a selector **304**. Then, the shading correction coefficient for each pixel is calculated in the shading correction coefficient generation unit **301** and the focus detection pixel shading correction coefficient generation unit **303**.

Reference numeral **303** denotes the focus detection pixel shading correction coefficient generation unit for generating a shading correction coefficient for a focus detection pixel from the shading correction coefficient S_norm for the normal pixel. The focus detection pixel shading correction coefficient generation unit **303** can generate four types of shading correction data, S_a_up, S_a_low, S_b_up, and S_b_low. Reference numeral **304** denotes the selector for selecting as a selection signal an address value output by the shading correction coefficient generation unit **301** from the five types of shading correction coefficients S_norm, S_a_up, S_a_low, S_b_up, and S_b_low. Reference numeral **305** denotes an image processing unit for carrying out digital signal processing other then the shading correction processing.

A method in the third embodiment is described, for calculating a shading correction coefficient for a focus detection pixel from a shading correction coefficient for a normal pixel by the focus detection pixel shading correction coefficient generation unit **303**. In the third embodiment, as in the second embodiment, the image sensor in FIG. **16** is used, and an enlarged view of a portion of the image sensor is as shown in FIG. **17**. In FIG. **17**, the upper left pixel and the lower right pixel are respectively referred to as an A pixel and a B pixel. Details of the pixels are described in the second embodiment, and are thus omitted here. Luminance shading in a general digital camera has shading characteristics of decrease in the amount of light with distance from the optical axis of a photographing lens. As for the A pixel, the upper left pixel with respect to the center of the image sensor **101** in FIG. **16** has an opening offset in the direction toward the optical axis of a photographing lens. On the other hand, the lower right A pixel has an opening apart from the optical axis of a photographing lens. Furthermore, as for the B pixel, the upper left pixel with respect to the center of the image sensor **101** in FIG. **16** has an opening apart from the optical axis of a photographing lens. On the other hand, the lower right B pixel has an opening offset in the direction toward the optical axis of a photographing lens.

Accordingly, in the third embodiment, when a shading correction coefficient for a focus detection pixel is obtained, the method for calculating the shading correction coefficient for the focus detection pixel is varied depending on the type of pixel, that is, whether it is a pixel offset toward the center of a photographing lens or a pixel apart from the center.

Furthermore, the normal pixels on the one hand, and the focus detection pixels as the A pixels and the B pixels on the other, are different from each other in the aperture of the opening of the image sensor **101**. The aperture of the focus detection pixel is smaller than that of the normal pixel. Therefore, in the third embodiment, for calculating a shading correction coefficient for a focus detection pixel, a shading correction coefficient for a normal pixel is multiplied by the ratio of the aperture of the focus detection pixel to the aperture of the normal pixel.

Here, the opening of the normal pixel is represented by α, whereas the aperture of the focus detection pixels (both the A pixel and the B pixel) is represented by β. In addition, a coefficient value applied to a focus detection pixel offset toward the optical axis of the photographing lens is represented by m, whereas a coefficient value applied to a focus detection pixel apart from the optical axis of the photographing lens is represented by n. Further, a shading correction coefficient for the upper left A pixel with respect to the optical axis of the photographing lens is represented by S_a_up, whereas a shading correction coefficient for the upper left B pixel with respect to the center of the lens is represented by S_b_up. Furthermore, a shading correction coefficient for the lower right A pixel with respect to the optical axis of the lens is represented by S_a_low, whereas a shading correction coefficient for the lower right B pixel with respect to the center of the lens is represented by S_b_low. Then, the shading correction coefficients are expressed by the following formula.

$$S\_a\_\mathrm{up}=S\_\mathrm{norm}\times(\alpha/\beta)\times m$$

$$S\_a\_\mathrm{low}=S\_\mathrm{norm}\times(\alpha/\beta)\times n$$

$$S\_b\_\mathrm{up}=S\_\mathrm{norm}\times(\alpha/\beta)\times n$$

$$S\_b\_\mathrm{low}=S\_\mathrm{norm}\times(\alpha/\beta)\times m$$

In the third embodiment, the A pixels and the B pixels are assumed to have the same aperture. However, if the A pixel and the B pixel have openings of different shapes, the aperture β for the focus detection pixel may be independently provided for each of the A pixel and the B pixel. In a similar way, the coefficient m or n may be separately provided for the A pixel and the B pixel.

Further, in the third embodiment, the shading correction coefficient for the focus detection pixel is obtained by the focus detection pixel shading correction coefficient generation unit **303**. However, the shading correction coefficient for the focus detection pixel may be calculated by the CPU **109** in FIG. **7**.

Next, shading correction processing in the third embodiment will be described with reference to a flowchart of FIG. **8**.

In step S**600**, it is determined whether or not image data (of one pixel) is input from the A/D conversion unit **105**.

When the image data is input ("YES" in step S**600**), it is determined in step S**601** whether or not shading correction data for the pixel to which the image data has been input is to be read out from the ROM **113**.

In a case in which it is determined in step S**601** that the shading correction data is to be read out ("YES" in step S**601**), the shading correction data is read out from the ROM **113** in step S**602**. The shading correction data in this case is shading correction data optimized for a normal pixel, for all of the pixels of the image sensor **101**.

In step S**603**, it is determined if the pixel to be now subjected to shading correction is the A pixel.

In a case in which it is determined in step S**603** that the pixel of interest is the A pixel ("YES" in step S**603**), it is determined if the pixel of interest is an upper left pixel with respect to the optical axis of the photographing lens in step S**604**.

In step S**605**, the shading correction coefficient S_a_up for the upper left A pixel with respect to the optical axis of the photographing lens is calculated from the shading correction data for the normal pixel which has been read from the ROM **113**. In this case, as described above, the shading correction coefficient S_a_up is calculated by the shading correction coefficient generation unit **301** and the focus detection pixel shading correction coefficient generation unit **303**.

In step S**606**, the shading correction coefficient. S_a_low for the lower right A pixel with respect to the optical axis of the photographing lens is calculated as described above from the shading correction data for the normal pixel which has been read from the ROM **113**.

Alternatively, in a case in which the pixel to be now subjected to shading correction is not the A pixel, it is determined in step S**607** if the pixel of interest is the B pixel.

In a case in which it is determined in step S**607** that the pixel of interest is the B pixel ("YES" in step S**607**), it is determined in step S**608** if the pixel of interest is an upper left pixel with respect to the optical axis of the photographing lens.

In step S**609**, the shading correction coefficient S_b_up for the upper left B pixel with respect to the optical axis of the photographing lens is calculated as described above from the shading correction data for the normal pixel which has been read from the ROM **113**.

In step S**610**, the shading correction coefficient S_b_low for the lower right B pixel with respect to the photographing lens is calculated as described above from the shading correction data for the normal pixel which has been read from the ROM **113**.

On the other hand, since the pixel to be now subjected to shading correction is a normal pixel in step S**611**, the shading correction coefficient S_norm for the normal pixel is calculated from the shading correction data read out from the ROM **113**. In this case, the shading correction coefficient S_norm is calculated by the shading correction coefficient generation unit **301**.

As described above, any of step S**605**, step S**606**, step S**609**, step S**610**, and step S**611** is executed depending on the type and position of the pixel of the input image data.

In step S**612**, the shading correction coefficient generated by the shading correction coefficient generation unit **301** or the focus detection pixel shading correction coefficient generation unit **303** is used to apply shading correction processing to the image data input in step S**600**.

In step S**613**, it is determined if the image data subjected to the shading correction processing in step S**612** corresponds to the last pixel read out from the image sensor **101**. If the image data corresponds to the last pixel ("YES" in step S**613**), the processing is completed. If not ("NO" in step S**613**), the processing returns to step S**600**, and again moves to determining if the next image data is input.

Fourth Embodiment

In the fourth embodiment, the difference between it and the first embodiment is described. FIG. **9** is a diagram illustrating a flowchart according to the fourth embodiment. Since each step of the processing shown in FIG. **9** is substantially the same as that in the flowchart of FIG. **4**, the same steps of the processing are denoted by the same reference numerals to omit the details of each step of the processing. However, the fourth embodiment is different in that, after reading out shading correction data for a focus detection pixel from the ROM **113** in step S**406**, a shading correction coefficient is calculated in the same way as for the normal pixel in step S**405**. In the first embodiment, the shading correction coefficient is stored in the ROM **113** as the shading correction data for focus detection pixels. Therefore, the data read from the ROM **113** is used as the shading correction coefficient without processing the data. By contrast, in the fourth embodiment, shading correction data is stored in a form from which a shading correction coefficient needs to be calculated even for focus detection pixels. Therefore, the shading correction coefficients are calculated. The shading correction coefficient for the focus detection pixels may be calculated in the same way as for the normal pixels, or may be calculated by different calculation methods.

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

This application claims the benefit of Japanese Patent Application Nos. 2008-061842, filed on Mar. 11, 2008, and 2009-043150, filed on Feb. 25, 2009, which are hereby incorporated by reference herein in their entirety.

The invention claimed is:

1. An image capturing apparatus comprising:

an image sensor that is configured to include photoelectric transfer portions which output a first pixel signal for focus detection and a second pixel signal for image recording;

a timing generation unit configured to output timing information for driving the image sensor;

a correction unit configured to sequentially determine whether a signal which is output from the image sensor and input to the correction unit in accordance with the timing information output by the timing generation unit is the first pixel signal or the second pixel signal, perform shading correction using a shading correction coefficient for a first image sensing pixel in a case where the input signal is determined as the first pixel signal in accordance with the timing information output from the timing generation unit, and perform shading correction using a shading correction coefficient for a second image sensing pixel in a case where the input signal is determined as the second pixel signal in accordance with the timing information output from the timing generation unit.

2. The image capturing apparatus according to claim **1**, further comprising a storage unit configured to store correction data for the signal,

wherein the correction unit calculates a shading correction coefficient for the second pixel signal based on correction data for the second pixel signal and uses the correction data for the first pixel signal as-is as shading correction coefficients for the first pixel signal.

3. The image capturing apparatus according to claim **1**, further comprising a determination unit configured to determine whether a pixel intended for shading correction is the first pixel signal or the second pixel signal, and, in a case in which the pixel intended for shading correction is the first pixel signal, determines a position of the pixel intended for shading correction in the image sensor,

wherein the correction unit performs shading correction depending on the determination result by the determination unit.

4. The image capturing apparatus according to claim **1**, further comprising a storage unit configured to store correction data for the first pixel signal and correction data for the second pixel signal as correction data for carrying out the shading correction,

wherein the correction unit corrects the second pixel signal based on the correction data for the second pixel signal, and corrects the first pixel signal based on the correction data for the first pixel signal.

5. The image capturing apparatus according to claim **1**, further comprising:

a calculation unit configured to calculate a defocus amount from an in-focus position, from the first pixel signal; and

a moving unit configured to move an optical system of the image capturing apparatus to the in-focus position, in accordance with the defocus amount.

6. An image processing method for signals output from an image sensor including photoelectric transfer portions which output a first pixel signal for focus detection and a second pixel signal for image recording, the image sensor included in an image capturing apparatus that also includes a correction unit and a timing generation unit configured to output timing information for driving the image sensor, said method comprising:

a determination step of sequentially determining, with the correction unit, whether a signal which is output from the image sensor and input to the correction unit in accordance with the timing information output by the timing generation unit is the first pixel signal or the second pixel signal;

a correction step of performing shading correction using a shading correction coefficient for a first image sensing pixel in a case where the input signal is determined as the first pixel signal in accordance with the timing information output from the timing generation unit, or performing shading correction using a shading correction coefficient for a second image sensing pixel in a case where the input signal is determined as the second pixel signal in accordance with the timing information output from the timing generation unit.

7. The image capturing apparatus according to claim **1**, wherein the correction unit is configured to correct the signal by multiplying it by a shading correction coefficient, wherein the shading correction coefficients vary between the first pixel signal and the second pixel signal.

8. The image capturing apparatus according to claim **7**, wherein the shading correction coefficients vary in accordance with a position of the photoelectric transfer portion.

9. The image capturing apparatus according to claim **1**, further comprising an image processing unit configured to perform image processing on the signal for image recording having undergone the shading correction by the correction unit.

10. The image capturing apparatus according to claim **1**, further comprising a focus detection unit configured to detect a focus state from the first pixel signal.

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